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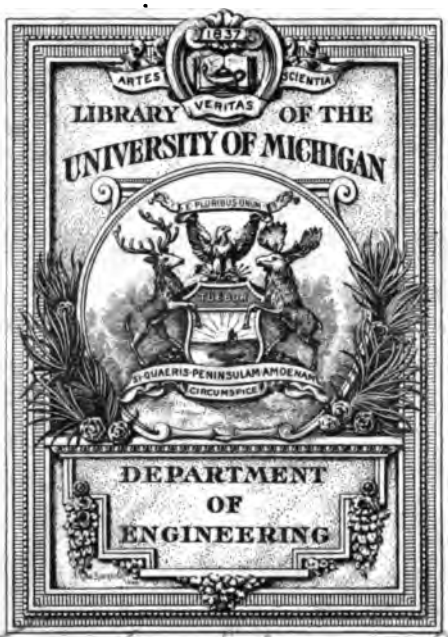

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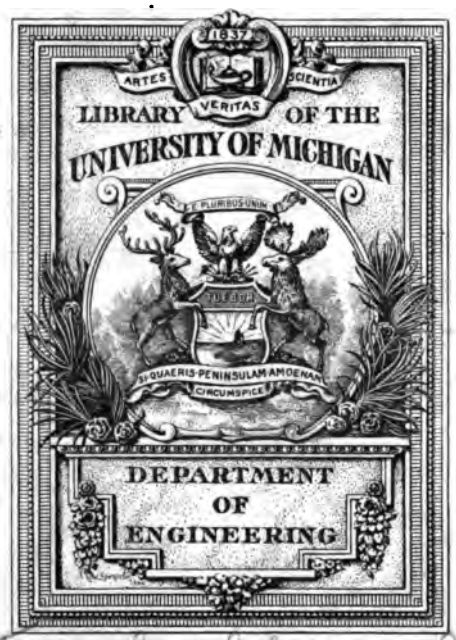

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OF THE

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OF

ENGINEERS AND SHIPBUILDERS.

EDITED BY THE SECRETARY OF THE INSTITUTION.

VOLUME XVI.

SIXTEENTH SESSION, 1899-1900.

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Boilers and Furnaces. Barr. 1899.
Chemical Analysis of Iron. Blair. 1898.
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Manual of Locomotive Engineering. Pettigrew and Ravensham. 1899.
Engineers' Sketch Book. Barber. 1897.
Resistance and Propulsion of Ships. Durand. 1898.
Commercial Management of Engineering Works. Burton. 1899.
Constructive Steam Engineering. Whitham. 1893.
Steam Engine Design. Whitham. 1898.
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Ascroft, Frederick W., 11 Park Street, Lytham ... . (E) May 1900
Atherton, William Henry, B.Sc., 113, Withington Road, Whalley Range, Manchester ... ... (E) Oct. 1891
Atkinson, F. C., 37, Croydon Road, Newcastle-upon-Tyne... ... (E) Dec. 1892
Atkinson, George H., 3, Acclom Street, Hartlepool ... ... (E) Nov. 1898
Atkinson, John Joseph, 7, Swiss Road, Elm Park, Fairfield, Liverpool ... ... (E) Mar. 1891

B.

Bagnall, T. W., The Groves, Winlaton ... ...(F M) Nov. 1893
Bailey, Charles H., Tyne Engine Works, Newport, Mon. ... ... (E) Mar. 1896
Bailey, James, 3, South Avenue, Ryton-on-Tyne ... ... (E) Nov. 1884
Bailey, James N., 3, South Avenue, Ryton-on-Tyne ... ... (E) Nov. 1898
Bailey, James T., 82, The Avenue, Wallsend-on-Tyne ... ... (E) Feb. 1899
Baines, Geo. Henry, c/o Messrs. W. Gray & Co., Central Marine Engine Works, West Hartlepool ... ... (E) Oct. 1888
Baird, Alexander, 9, Delaval Road, Whitley Bay, Northumberland (E) Oct. 1898
Baird, George, 25, Newcastle Road, North Shields ... ... (E) Oct. 1892
Baird, Robert, 13, Hylton Terrace, North Shields ... ... (E) Jan. 1890
Baker, E. F., H.M.S. "Magdala," Bombay, British India ... . (E) { Graduate, Nov. 1892 / Member, Feb. 1898
Barbour, John, South View House, South Shields... (E) { Graduate, Nov. 1890 / Member, Oct. 1898
Barclay, James, Lloyd's Register of Shipping, Swansea ... ...(SUR) Nov. 1888
Barley, C. J., c/o Messrs. The London Electric Supply Corporation, Stowage Wharf, Deptford, London, S.E. ...(E) { Graduate, Feb. 1885 / Member, Dec. 1886

ELECTED.

Barley, Wm. M. F., 14, Croft Terrace, Jarrow-on-Tyne ... ... (F) Nov. 1899
Barnard, Robert, 11, Guildford Place, Heaton, Newcastle-upon-Tyne ... ... (E E) Mar. 1899
Barnett, James Rennie, Westfield, Crookston, Renfrewshire, N.B. (S) Oct. 1889
Barrett, A., Staith House, West Hartlepool ... ... (E) May 1896
Barron, T. G., Hobourne, Elswick Road, West Hartlepool ... (E) Oct. 1888
Batey, John Thomas, 25, Harrison Place, Newcastle-upon-Tyne ... (S) Nov. 1885
Batliboi, Jehangir Framji, 71, Apollo Street, Fort, Bombay ... (E) Dec. 1888
Baxter, J., 26, Simonside Terrace, Heaton, Newcastle-upon-Tyne (E) Nov. 1884
Beadon, D. C., "Stoneham," Beech Grove Road, Newcastle-upon-Tyne... ... ... (E) Jan. 1885
Beilby, Norman Harry, 1, Kingsley Place, Newcastle-upon-Tyne... ... ... (E) { Graduate, Dec. 1893; Member, Dec. 1899
Bell, Geo. Arthur. 48, Crown Street, Newcastle-upon-Tyne (E) { Graduate, Oct. 1890; Member, Jan. 1894
Bell, Joshua Robson, 40, Hill Street, Jarrow-on-Tyne ... ... (S) Mar. 1899
Bell, William, Messrs. Cleland's Slipway Co., Willington Quay-on-Tyne ... ... (E) Nov. 1888
Bell, William T., 175, Coatsworth Road, Gateshead-on-Tyne ... (E) Nov. 1898
Bennet, Percy M., 190, Heaton Road, Newcastle-upon-Tyne ... (E E) Dec. 1899
Berkley, A. B., Kent Villas, Jarrow-on-Tyne ... ... (E) Mar. 1887
Bigge, D. L. Selby, 27, Mosley Street, Newcastle-upon-Tyne ... (E E) Nov. 1894
Billetop, Torben Christian, 3, Guildford Place, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1896
Bindesböll, S. C. W., Aktieselskabet Helsingors Jernskibs- og Maskinbyggeri Helsingor, Denmark ... ... (S) Nov. 1884
Binns, Aubrey B., 23, Thornhill Terrace, Sunderland ...(E) { Graduate, Oct. 1894; Member, Dec. 1899
Black, J., 1, Church Street, West Hartlepool ... ... (E) Nov. 1888
Black, Wm., 1, Lovaine Place, Newcastle-upon-Tyne ... ... (E) Jan. 1885
Blackett, Walter, 19, Valletort Road, Stoke, Devonport ... ... (E) { Graduate, Nov. 1886; Member, Nov. 1892
Blackie, Thomas Reid, Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London ... ... (SUR) Nov. 1890
Blake, James, Northbrook, Linthorpe, Middlesbro' ... ... (E) Nov. 1899
Blenkinsop, John N., Marine Supt. Engineer, Great-Eastern Railway, Parkeston Quay ... ... (E) Oct. 1885
Blomberg, Carl A., 2262, North 19th Street, Philadelphia, Pa., United States of America ... ... (E) Oct. 1896
Blow, Charles, 104, Meldon Terrace, Heaton, Newcastle-upon-Tyne... ... ... (E) Nov. 1898
Blumer, Wm., Woodside, Sunderland... ... ... (S) Dec. 1886
Boddy, John, 96, Dock Street, Newport, Monmouthshire ... ... (E) Dec. 1888
Bodin, Lauritz M., 58, John Street, Sunderland ... ... (E & SUR) Dec. 1889
Bomphrey, Archibald M., 25, James Watt Terrace, Barrow-in-Furness ... ... (S) Oct. 1898
Bone, W. J., 61, Linskill Terrace, North Shields ... ... (S) Dec. 1884
Bonnyman, James Smith, 64, Plasturton Avenue, Cardiff... ... (E) Nov. 1889
Boolds, Jas. H., Woodlands Road, Middlesbrough ... ... (S) Oct. 1886
Booth, Edward Spence, Box 5124, Boston, U.S. America ...(M S & N A) Oct. 1889
Booth, John William, Union Foundry, Rodley, near Leeds ... (E) April 1892

ELECTED.

Borrowman, William Cameron, Wh.Sch., Newstead, Grange Road, West Hartlepool ... ... (E) Oct. 1898
Bosi, Guiseppe, Presso Rastelli, Sampierdarena, Genoa, Italy (E & NA) Jan. 1894
Bowden, John, Sheriff Mount, Gateshead-on-Tyne (E) { Graduate, Jan. 1894; Member, Oct. 1898 }
Boyd, Arthur, Lloyd's Register of Shipping, Bute Docks, Cardiff (E SUR) May 1895
Boyd, Wm., North House, Long Benton, Newcastle-upon-Tyne ... (E) Nov. 1884
Boyt, John T., 302, Walnut Street, Philadelphia, Pa., U.S.A. ... (E) Nov. 1893
Bramwell, Balfour, c/o Messrs. Harland & Wolff, Engine Works, Belfast ... ... (E) { Graduate, Nov. 1886; Member, Nov. 1887 }
Brankston, R. T., 36, Hawthorn Street, Newcastle-upon-Tyne ... (E) Nov. 1884
Brash, James, c/o Messrs. Ernest Scott, Mountain & Co., Close Engine Works, Newcastle-upon-Tyne ... ... (E E) Nov. 1897
Brew, George, c/o Messrs. Furness, Withy & Co., steamship owners, Montreal ... ... (SUR & C E) May 1896
Brigham, Robert F., 5, Argyle Terrace, South Shields ... ... (E) Mar. 1897
Broadbent, Frank, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Nov. 1893
Brock, Henry W., c/o Messrs. Wm. Denny & Bros., Dumbarton (E & S) Nov. 1899
Brockett, Charles, 35, Milton Road, West Hartlepool ... ... (E) Feb. 1899
Brotherston, James, 2, Salisbury Street, Sunderland ... ... (E) Oct. 1895
Brown, Eugene, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Feb. 1886
Brown, Geo. Matthew, Birk Heads, Marley Hill, Swalwell, R.S.O. ... ... (E) { Graduate, April 1895; Member, Nov. 1897 }
Brown, James, c/o Sociedad Anonima, de los Astilleros del Nervion, Bilbao, Spain ... ... (E) Mar. 1891
Brown, Percy J., Salem Cottage, Sunderland ... ... (E) May 1899
Brown, Robson, 32, Salmon Street, South Shields ... ... (E) Nov. 1889
Brown, T. R., 27, Ripon Street, Sunderland ... ... (E) { Graduate, May 1885; Member, Oct. 1886 }
Brown, William, c/o Messrs. Siemens Brothers & Co., Woolwich... (E) April 1887
Browne, Sir B. C., Westacres, Benwell, Newcastle-upon-Tyne (C E) Jan. 1885
Buchanan, A., Michaelson Villa, Barrow-in-Furness ... ... (S) Nov. 1884
Buchanan, John H., Oswald Chambers, 5, Oswald Street, Glasgow (SUR) Oct. 1888
Buckland, H. B., Baltic Chambers, Quayside, Newcastle-upon-Tyne (E) Nov. 1885
Buckwell, George William, Board of Trade Surveyor's Offices, Sunderland... ... ...(SUR) Oct. 1896
Bull, John Catharinus, 29, Bexley Heath, Erith, Kent ... ... (E) Oct. 1892
Bulmer, Frederick Charles, 2, Graingerville North, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894; Member, Oct. 1895 }
Bulmer, John, 2, Graingerville North, Newcastle-upon-Tyne ... (E) Mar. 1886
Bulmer, John George, 34, Brighton Grove, Newcastle-upon-Tyne (E) May 1894
Bulmer, Septimus, 49, Brighton Grove, Newcastle-upon-Tyne... ... ... (E) { Graduate, May 1894; Member, Dec. 1899 }
Burbidge, Alfred H., Backwell Rectory, Bristol ... (E) { Graduate, Oct. 1895; Member, Oct. 1898 }
Burnett, Norman, Watergate Buildings, Newcastle-upon-Tyne ... (E) Oct. 1891
Burney, Charles E., Lloyds Registry of Shipping, 12, Oriel Chambers, Liverpool ... ...(SUR) Nov. 1898
Bush, Montague ... ... (E E) Nov. 1896
Bushell, Chas. A., 1, Benton Terrace, Newcastle-upon-Tyne (N A & SUR) Nov. 1893

ELECTED.

Butterfield, George, 4, Kayll Road, Sunderland ... ... (S) Nov. 1884
Butterworth, George Herbert, 53, Park Crescent, North Shields... (E) Nov. 1899
Buchan-Sydserff, Thos., 2, Claremont, Knowle Road, Bristol ... (E) Oct. 1888
Byers, Wm. Lumsden, 11, Norfold Street, Sunderland ... ... (E) May 1900

C.

Cairns, C. W., M. Sc., 4, Hollow Lane, New Barns, Barrow-in-Furness ... ... (E) { Graduate, Nov. 1894; Member, Dec. 1897
Carr, Wilson Story, 14 Percy Gardens, Tynemouth ... ... (C E) May 1900
Carverhill, E. A., 19, Crown Street, Newcastle-upon-Tyne... ... ... (E E) { Graduate Oct. 1898; Member, Dec. 1899
Cama, Nusserwanji Bomanji, Sleater Road, Tardeo, Bombay, British India ... ... (E) Dec. 1888
Cameron, Angus, c/o Sir James Laing, Bart., Deptford Yard, Sunderland ... ... (S) Nov. 1892
Campbell, J. Jennings, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (E) Oct. 1888
Campbell, John M., 4, Winchester Terrace, Newcastle-upon-Tyne (N A) April 1895
Campbell, Thomas, c/o Messrs. Hills Dry Dock Co., Cardiff ... (S) Mar. 1894
Camps, H. E. J., 25, Cross Street. Islington, London, N. ... ... (S) Oct. 1894
Canning, Chas. E., c/o Messrs. Burmeister & Wains, Shipbuilders, Copenhagen, Denmark ... ... (S) { Graduate, Dec. 1897; Member, Nov. 1899
Cannell, Frank, Messrs. H. Parry & Son, Lisbon ... ... (E & S) Nov. 1887
Carney, J. H., Glengariffe, Stow Park, Newport, Monmouth ... (E) Mar. 1897
Carstons, Samuel, Messrs. Burmeister & Wains, Maskin-og Skibsbyggeri, Copenhagen, Denmark... ... ... (S) Dec. 1887
Carter, Geo. J., Elswick Shipyard, Newcastle-upon-Tyne... ... (N A) Dec. 1897
Casey, James, 10, Philpot Lane, London, E.C. ... ... (E) Nov. 1891
Ceuvel, John L., 763, Gulgenstug, Naarden, Holland ... ... (E) Mar. 1886
Chambers, John, 114, Sidney Grove, Newcastle-upon-Tyne ... (E) Dec. 1897
Chapman, Harry Reynolds, Messrs. Clarke, Chapman & Co., Gateshead-on-Tyne ... ... (E) Mar. 1893
Charlton, Henry, 1, Millfield Terrace, Gateshead-on-Tyne ... (E) Nov. 1884
Charlton, R. B., Jun., Manors Railway Station Works, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Charlton, T., 25, Lincoln Street, Gateshead-on-Tyne ... ... (E) Nov. 1884
Charlton, Thomas, The Cedars, Millhill, West Cowes, Isle of Wight (E) Nov. 1890
Chaston, Edward Catmore, 27, Larkspur Terrace, Newcastle-upon-Tyne ... ... (E) Oct. 1894
Cherry, Thos. Wm. Fry, c/o Messrs. The Greenock Foundry Co., Greenock ... ... (E) Oct. 1894
Chicken, Thomas. c/o Messrs. Newport Engineering and Ship Repairing Co., Newport. Monmouth ... ... (E) Oct. 1892
Chilton, Joseph, 73 Theresa Street, Blaydon-on-Tyne ... ... (E) Dec. 1899
Chisholm, Alexander, 92, George Road, Wallsend-on-Tyne ... (S) Mar. 1893
Christie, C. J. D., Neptune Works, Walker-on-Tyne ... ... (S) Nov. 1884
Christie, J. D., Woodside, Tynemouth ... ... (S) Nov. 1884
Christie, Reginald, Woodside, Tynemouth ... ... (E E)
Christie, David M., 95, Great Western Road, Glasgow ... ... (E) Mar. 1900
Clague, James Henry, Birkenhead Ironworks, Birkenhead ... ... (S) { Graduate, April 1891; Member, May 1894

ELECTED.

Clark, Charles, c/o Messrs. Robert Irvine & Co., Tower Chambers, West Hartlepool ... ... (E) Jan. 1897
Clark, Geo., Southwick Engine Works, Sunderland ... ... (E) Nov. 1884
Clark, George, Jun., Southwick Engine Works, Sunderland ... (E) Feb. 1888
Clark, Henry, Southwick Engine Works, Sunderland ... ... (E) Oct. 1887
Clarke, Harry, Lloyd's Register of Shipping, Leith ... ... (E) Mar. 1897
Clarke, Henry Trevisa, Deptford Shipyard, Deptford, Sunderland (S) Mar. 1892
Clarke, William Henry, 6, Bolton Terrace, Newcastle-on-Tyne ... (E) Dec. 1896
Cleghorn, Alexander, Datcha, Scotstounhill, near Glasgow ... (E) Feb. 1897
Coates, Matthew C., 26, Denmark Street, Gateshead-on-Tyne ... (E) Nov. 1897
Cohn, William M., 2, Marine Terrace, North Shields ... ... (S) Nov. 1893
Coleby, James W., 42, Burns Terrace, Willington Quay-on-Tyne ... ... (E) Graduate, Oct. 1891; Member, Jan. 1894
Coletti, Silvio, 15, Via Masone Bergano, Italy ... ... (S) Dec. 1895
Common, John B. A., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ... (E) April 1896
Conràdi, Carl, Prinsens Gade 2b, Christiania, Norway ... ... (E) Nov. 1884
Consiglio, Luigi, 8, Via Paterno, Palermo ... ... (N A) Nov. 1890
Cookson, John A., 26, Whitehall Road, Gateshead-on-Tyne ... ... (E) Graduate, Dec. 1895; Member, Nov. 1897
Cooper, Burjorjee S. N., Sea View, Mahim, Bombay, British India (E) May 1900
Cooper, Sidney ... ... (E) Graduate, Nov. 1891; Member, May 1895
Coote, Arthur, Messrs. R. & W. Hawthorn, Leslie, & Co., Hebburn-on-Tyne ... ... (S) Nov. 1884
Cornish, H. P., Lloyd's Register of Shipping, 28, Kattendyk, Ouest Quai, Antwerp ... ... (E) Oct. 1888
Couche, Henry Drew, c/o Messrs. Laird Bros., Birkenhead ... (S) Oct. 1891
Coull, Alex. B., Baltic Chambers, Newcastle-upon-Tyne ... ... (C E) Jan. 1898
Courtier-Dutton, W. T., British Corporation Registry of Shipping, 69, St. Vincent Street, Glasgow... ... ... (S SUR) April 1890
Cowan, Robert, 14, Osborne Avenue, South Shields ... ... (E) Dec. 1896
Cowens, William Edward, c/o Messrs. John Abbot & Co., Gateshead-on-Tyne ... ... (E) Dec. 1889
Craggs, Adolphus, Ivy House, Pelton, Chester-le-Street (E) Graduate, Dec. 1897; Member, Nov. 1899
Craggs, Ernest H., Messrs. R. Craggs & Sons, Middlesbrough ... (S) Oct. 1888
Craig, Robert, Pageland House, Grange Road, West Hartlepool ... (E) Nov. 1892
Crawford, Jas., 8, Salmon Terrace, South Shields ... ... (S SUR) Nov. 1886
Crofton, Charles, 17, Albany Terrace, Whitley Bay, Northumberland ... ... (E) Nov. 1895
Crookston, John, 72, Mark Lane, London, S.E. ... ... (E) Mar. 1896
Cruddas, W. D., M.P., Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick, Newcastle-upon-Tyne ... ... (E) Dec. 1884
Cruickshank, Alexander, The Admiralty, Albany Buildings, 47, Victoria Street, London, S.W. ... ...(SUR) Mar. 1892
Cumming, William, c/o Mr. Hyslop, Hampton House, Grey Street, St. Kilda, Melbourne, Australia ... ... (E) Mar. 1896
Cummins, W. R., 17, Victoria Street, Loughborough ... ... (E) Nov. 1884
Cunliffe, Tom Arthur, 26, Ormonde Street, Chester Road, Sunderland ... ... (E) Feb. 1897

ELECTED.

D.

Dale, John, 23, Whitehall Terrace, Hylton Road, Sunderland ... (E) Mar. 1897
Dalrymple, Wm., Myrtle Cottage, nr. Cleadon, Sunderland ... (E) Dec. 1886
Dalrymple, William, Jun., 8, Amberley Terrace, Sunderland ... (E) Dec. 1895
Darling, W. J., Lloyd's Register of Shipping, Dock Chambers, Barry ... ... (S) April 1887
Darney, John, c/o Messrs. Short Bros., Pallion, Sunderland ... (S) Nov. 1884
Davis, Thos. Wilfrid, Birkenfeld, Bromley, Kent ... (E) { Graduate, Jan. 1891 / Member, Mar. 1894
Dawson, Herbert, 7, Cuthbert's Terrace, Gateshead-on-Tyne ... (E E) Nov. 1897
Deighton, William, Messrs. Deighton's Patent Flue Co., Vulcan Works, Pepper Road, Leeds ... ... (E) Nov. 1897
Denny, Archibald, c/o Messrs. Denny & Co., Dumbarton ... ... (S) Dec. 1891
Denny, Leslie, c/o Messrs. Wm. Denny & Bros., Dumbarton ... (S) Nov. 1899
Denny, Peter, Bellfield, Dumbarton ... ... (E & S) Nov. 1899
De Rusett, Edwin W., Warden House, Percy Park Road, Tynemouth ... ... (S) Nov. 1890
Detchon, John, 115, Bell Terrace, Newcastle-upon-Tyne ... ... (E) Feb. 1899
Dick, F. W., c/o Messrs. Palmer's Shipbuilding Co., Jarrow-on-Tyne... ... ... (I & S M) Oct. 1891
Dickie, James, 428, Mississippi Street, Potrero, San Francisco, California, U.S.A.... ... ... (S) Mar. 1894
Dickie, John P., 18, Brinkburn Terrace, South Shields (E) { Graduate, Mar. 1898 / Member, May 1900
Dickinson, F. T., 23, Park Place W., Sunderland ... (E) { Graduate, May 1885 / Member, Oct. 1886
Dickinson, James C., The Cloisters, Sunderland ... ... (E) Nov. 1884
Dickinson, John, Park House, Sunderland ... ... (E) Nov. 1884
Dickinson, W., The Club, Sunderland ... ... (E) Nov. 1884
Dietze, F. G., Messrs. The Hamburg South American Steam Ship Company, Hamburg ... . (E) Nov. 1893
Dippie, Joseph Robt., 130 Albert Road, Jarrow-on-Tyne ... ... (S) April 1900
Dixon, James, c/o Messrs. Ropner & Sons, Shipbuilders, Stockton-on-Tees ... ... (E) Dec. 1893
Dixon, John Rochester, 79, Osborne Road, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1887 / Member, Feb. 1893
Dixon, Sir Raylton, Cleveland Shipyard, Middlesbrough ... ... (S) Feb. 1888
Dixon, William John, R.N., H.M.S. "Renown," Mediterranean Squadron... ... ... (E) { Graduate, Mar. 1896 / Member, Nov. 1899
Dobson, Henry James, c/o Messrs. William Dobson & Co., Newcastle-upon-Tyne ... ... (S) { Graduate, Oct. 1891 / Member, Feb. 1898
Dobson, John T., 42, Ripon Street, Sunderland ... ... (S) May 1899
Dobson, William, Shipbuilder, Walker-on-Tyne ... ... (S) Nov. 1888
Donald, James, 58, General Gordon Terrace, Sunderland ... ... (S) Nov. 1884
Donkin, George, St. Andrew's Engine Works, Newcastle-upon-Tyne (E) Oct. 1892
Donovan, J. W., 5, Ash Place, Newcastle Road, Sunderland ... (E) April 1885
Dos Santos, Apolinaris J., Rio Grande-do-Sul, Brazil ... (SUR) Nov. 1891
Douglas, John F., c/o Messrs. Ramage & Ferguson, Leith... ... (E) Jan. 1888
Dove, Herbert J., 25, Ashfield Terrace W., Newcastle-upon-Tyne (E) Nov. 1896
Downing, Nicholas, Glenbrooke, Victoria Avenue, Norton Road, Stockton-on-Tees ... ... (I F) Oct. 1894

ELECTED.

Dowsen, Chas., 21, Croft Terrace, Jarrow-on-Tyne... ... ... (E) Dec. 1885
Doxford, Albert Ernest, M.A., 1, Grange Crescent, Sunderland... ... ... (E) { Graduate, Oct. 1890 / Member, Nov. 1893
Doxford, Charles D., Bainbridge Holme, Tunstall Road, Sunderland (S) Nov. 1884
Doxford, Robert P., Pallion Engine Works, Sunderland ... ... (E) Nov. 1884
Doxford, W. Theodore, M.P., Pallion Shipyard, Sunderland ... (S) Nov. 1884
Dressler, Gustav, Angelburger Strasse 54, Flensburg, Bremen ... (E) Jan. 1900
Duckitt, Jno., Leazes Gate Villa, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Duckitt, John Brentnall, 20, George Lane, Woodley, *via* Stockport, Cheshire... ... ... (E E) { Graduate, Oct. 1888 / Member, April 1895
Duckitt, Talbot, 12, Leopold Street, Loughborough (E E) { Graduate, Oct. 189 / Member, Oct. 189
Dudgeon. F. S., 30, Great St. Helens, London, E.C. ... ... (E) Feb. 1885
Dugdale, William H., Wear Dock Yard, Sunderland ... ... (S) Mar. 1894
Duguid, Robert, c/o Messrs. Harland & Wolff, Drawing Office Department, Belfast ... ... (S) Oct. 1892
Duncan, George Thos., c/o Messrs. Tangyes Limited, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (E) Nov. 1894
Dunlop, John, c/o Messrs. Clyde Shipbuilding and Engineering Co., Glasgow ... ... (S) Mar. 1898
Dunlop, William, c/o Messrs. Odero fu Aless°., Sestri-Ponente, Italy (E) Mar. 1888
Dykes, George, Lloyd's Register of Shipping, Steinhoeft 3, Hamburg ... ... (S) Jan. 1893
Dykes, James, 82, Park Road, Newcastle-upon-Tyne ... ... (E) May 1885
Dykes, John, Lloyd's Register of Shipping, Oriel Chambers, Liverpool ... ...(SUR) Oct. 1889

E.

Eason, Th^s., 22, Woodbine Road, Gosforth, Newcastle-upon-Tyne (E) April 1899
Edminson, Frank A., Ormidale, Otterburn Villas, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Nov. 1897
Edmiston, Jas. B., Ivy Cottage, Highfield Road, Walton, Liverpool (E) Nov. 1886
Edwards, Guy W., 80, Osborne Road, Newcastle-upon-Tyne ... (E) Mar. 1897
Edwards, James Harry, Jun., High Docks, South Shields... ... (S) Mar. 1893
Eeles, Robert, Queen Street, Newcastle-upon-Tyne ... ... (E) April 1889
Eidman, William, 6, Bradford Place, Penarth ... ... (E) Nov. 1897
Elder, Edward, c/o Messrs. J. & G. Thomson, Clydebank, Glasgow ... ... (S) { Graduate, Nov. 1890 / Member, Oct. 1892
Elliott, William D., Hessle, Hull ... ... (E) Nov. 1894
English, Thos. (Lieut.-Col.), Hawley, near Dartford, Kent ... (E) Oct. 1890
Eshelby, William. 13, Brankingham Terrace, Norton Road, Stockton-on-Tees ... ... (E) Feb. 1888
Evans, Lewis. c/o Ralph Carr, Esq., Maritime Buildings, King Street, Newcastle-upon-Tyne ... ...(SUR) Dec. 1890
Evans, William, Superintendent Engineer, Rosedene, Whitchurch, Cardiff ... ... (E) Nov. 1889
Eyres, Reginald J., 8, Murton Street, Sunderland ... ... (C E) Feb. 1900

F.

Fairbairn, James. 54, Amberley Street, Sunderland (E) { Graduate, May 1885 / Member, April 1895

ELECTED.

Farina, A. J., 63, Quayside, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Farminer, A. E., c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (SUR) Jan. 1900
Farquharson, Geo. James, c/o Messrs. Elder, Dempster & Co., Luisenhof, Neue Gröninger Strass, 1, Hamburg ... ... (E) April 1899
Fenwick, James, B.Sc., C.E., 19, Bridge Street, Sydney, New South Wales ... ... (E) Oct. 1892
Fernandes, Charles B. L. ... ... (E E) Jan. 1899
Ferrier, Robert M., B.Sc., Durham College of Science, Barras Bridge, Newcastle-upon-Tyne ... ... (E) Nov. 1892
Fettes, James, c/o Messrs. R. E. Mudie & Sons, Marine Buildings East, Dock Street, Dundee ... ... May 1899
Field, Arthur M. C., 63, Great Georges Street, Leeds ... ... (E E) Jan. 1898
Finch, Herbert K., Colliery Agent, Tower House, Preston, Lancashire ... ... (E) { Graduate, Dec. 1888; Member, Nov. 1894
Fish, Thomas Wilson, Lloyd's Register of Shipping, Calcutta, British India ... ...(SUR) May 1892
Fleming, Charles Edward, 71, Elswick Road, Newcastle-upon-Tyne (E) Nov. 1884
Fletcher, Robert, Walker Forge, Walker-on-Tyne ... ...(F M) Dec. 1886
Flohr, Justus, Director der Stettiner Maschinenbau-Actien-Gesellschaft "Vulcan," Rantstrasse 9, Stettin ... ... (E) Oct. 1886
Foley, Wm. C. le B., 3008, West Avenue, Newport News, Virginia, U.S.A. ... ... (S) { Graduate, Nov. 1887; Member, Oct. 1892
Ford, John McLaren, 70, Mount Pleasant, Barrow-in-Furness ... (S) Nov. 1896
Forster, Alfred Lindsay, c/o Messrs. Clark, Chapman & Co., Ltd., Victoria Works, Gateshead ... ... (E) { Graduate, Nov. 1891; Member, Oct. 1895
Forster, William, c/o Messrs. Dixon, Robson & Co., 2, Collingwood Street, Newcastle-upon-Tyne ... ... (E) Mar. 1890
Foster, Henry, c/o Messrs. Galloway & Co., Knott Mills Ironworks, Manchester ... ... (E) April 1885
Foster, L. P., Trevillis, Liskeard, Cornwall ... ... (E) { Graduate, Nov. 1893; Member, Oct. 1898
Fothergill, J. R., 1, Bathgate Terrace, West Hartlepool ... ... (C E) Mar. 1886
Fownes, Henry, 6, Osborne Road, Jesmond, Newcastle-upon-Tyne (F M) Nov. 1884
Fox, Carter, 7, Coxon Street, Sunderland, ... (E) { Graduate, Feb. 1898; Member, Dec. 1899
Fox, Samson, Messrs. The Leeds Forge Co., Leeds (*Life Member*) (E) Dec. 1887
Fox, William. 9, Winfield Terrace, Chester Road, Manchester ... (E) April 1895
France, Alfred Brown, 12, Bright Street, Middlesbrough ... (E) Feb. 1900
Franki, J. P., c/o Messrs. Morts Dry Dock and Engineering Co., Sydney, N.S.W., Australia ... ... (E) Jan. 1886
Fraser, John Holt, 48, Balliol Road, Bootle, Liverpool (E) { Graduate, Oct. 1895; Member, Jan. 1898
Fraser, Thomas S., 1, The Hollies, Armley, Leeds ... ... (E E) Jan. 1894
Fuller, Philip S., 189, Cardigan Terrace, Gateshead-on-Tyne ... (E) Nov. 1899
Furneaux, J. B., Victoria Engine Works, Gateshead-on-Tyne ... (E) Nov. 1885
Furse, Fred., c/o Messrs. Hawthorn, Guppy & Co., Engineers, Naples ... ... (S) April 1887

G.

Gaine, Roger L., Moor House, Hartlepool ... ... (E) { Graduate, Dec. 1887; Member, Oct. 1894

ELECTED.

Gannaway, H. G., 12, Croft Terrace, Jarrow-on-Tyne ... ... (S) Nov. 1884
Garelli, Fabio, c/o Messrs. Odoro fu Aless°, Sestri-Ponente, Italy (S) Oct. 1896
Garmey, John ... ... (E) Dec. 1898
Garthwaite, John R., c/o Messrs. R. Ropner & Sons, Stockton-on-Tees (S) May 1889
Gates, George, Walworth Road, Park Road, West Hartlepool ... (E) Jan. 1899
Gayner, Robt. H., Jun., Beech Holm, Sunderland ... (E) Graduate, Mar. 1886; Member, Oct. 1888
Gearing, Ernest George, Penshurst, Clarence Drive, Harrogate ... (E) Dec. 1892
Geddes, Christopher, 2A, Drury Lane, Water Street, Liverpool ... (E) Oct. 1888
Gibson, H., 162, Roker Avenue, Monkwearmouth, Sunderland ... (S) Nov. 1884
Gibson, J. Hamilton, c/o Messrs. Laird Bros., Birkenhead (E) Graduate, April 1891; Member, Oct. 1894
Gibson, Thomas, 81, Corporation Road, Cardiff ... (E) Graduate, Nov. 1893; Member, Dec. 1897
Gibson, W. H., 37, Tatham Street, Sunderland ... ... (E) Nov. 1884
Golledge, William, Royal Agricultural Hall, Islington, London ... ... (E E) Graduate, Nov. 1891; Member, Nov. 1896
Good, Farrant, c/o Messrs. Bute Dry Dock Co., Ltd., Roath Basin, Cardiff ... ... (E) Mar. 1896
Gordon, William James, c/o Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Oct. 1887
Gordon, William Leslie, Invermark, Broughty Ferry, N.B. ... (E) April 1893
Graham, James Thos., 126, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1897
Graham, William, c/o Messrs. Osbourne, Graham & Co., Hylton, near Sunderland ... ... (S) Nov. 1884
Graham, William, West House, Tynemouth ... ... (S) Oct. 1891
Graham, William, 30, Hill Street, Jarrow-on-Tyne ... ... (S) April 1893
Graham, William, Rockcliffe, Redbrink Crescent, Barry Island, South Wales ... ... (E) Nov. 1894
Gravell, John, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (N A SUR) Nov. 1884
Gray, A., 1, South Parade, Newcastle-upon-Tyne ... ... (E) Nov. 1888
Gray, George, 3, Cedars Crescent, Ryhope Road, Sunderland ... (E) Feb. 1888
Green, W. G., Rose Hill, Willington Quay-on-Tyne ... ... (E) Nov. 1884
Greenhow, John, 1, Bright Street, Middlesbrough ... ... (S) Oct. 1894
Greig, David William, 31, Westmoreland Road, Newcastle-upon-Tyne ... ... (E) Mar. 1891
Giacomuzzi, Virgilio, c o Messrs. Nicolo Odero fu Alessandes, Sestri Ponenti, Italy ... ... (N A) Nov. 1899
Grey, Charles, 17, Lovaine Crescent, Newcastle-upon-Tyne ... (E) Feb. 1898
Griffith, Edwin, Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (E) Nov. 1897
Grimes, Thomas Benjamin, 39, Vespasian Avenue, South Shields... (E) Mar. 1890
Gross, Felix, 47, Queen's Terrace, Newcastle-upon-Tyne ... (I & S M) Feb. 1893
Guiston, A., Clayton Park Lodge, Jesmond, Newcastle-upon-Tyne (E) Dec. 1888
Gunn, Sir John, Chairman, Messrs. Mount Stuart Dry Docks Co., Cardiff (*Life Member*) ... ... June 1896

H.

Hall, Edward, 68, Grange Road West, Jarrow-on-Tyne ... ... (S) Nov. 1885
Hall, J. Percy, Carville, Lawrie Park Road, Sydenham, London, S.E. (E) Oct. 1885

ELECTED.

Hall, John, 54, Westoe Parade, South Shields ... ... (E) May 1900
Hall, Thomas, 29, Selbourne Road, Ilford, London, E. ... ... (E) Nov. 1899
Hallowell, William, 75, Chillingham Road, Heaton, Newcastle-upon-Tyne ... ... (E) Feb. 1899
Hamilton, Robert C., The College, Durham... ... (E) { Graduate, Dec. 1892 / Member, Oct. 1895
Hammar, Hugo G., Lindholmens, Verkstads Alstieholag, Göteberg, Sweden ... ... (S) Nov. 1890
Haramüshi, M., Jun., 156, Hommachi Köchi, Tosa, Japan ... (N A) Nov. 1897
Harbottle, John, Wh.Sch., 63, Malvern Street, Newcastle-upon-Tyne ... ... (E) Oct. 1896
Harbottle, Thomas, 5, Alexander Terrace, Newcastle-upon-Tyne (E) Jan. 1900
Hardy, Henry Thomas, 10, The Retreat, Sunderland ... ... (S) Dec. 1899
Harkness, Richard, Grange Road, West Hartlepool ... (S SUR) Nov. 1884
Harlow, F., 8, Benton Terrace, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Harman, Bruce, Messrs. The Linde British Refrigerating Co., 35, Queen Victoria Street, London, E.C. ... ... (E) Oct. 1886
Harper, J. H., 1, Beaumont Street, North Shields ... ... (E) Jan. 1885
Harris, Anthony, 73, Queen Victoria Street, London, E.C. ... (E) Mar. 1892
Harrison, Alfred, Scotia Engine Works, Sunderland (*Life Member*) (E) Oct. 1889
Harrold, Alexander, 26, Park Road, Newcastle-upon-Tyne ... (E) Nov. 1884
Harrold, F., 140, Cardigan Terrace, Heaton, Newcastle-upon-Tyne (E) Nov. 1888
Harroway, George Mitchell, 18, West Terrace, North Ormesley, Middlesbrough ... ... (S) Jan. 1896
Hartley, W. A., c/o Messrs. Charles Cammell & Co., Cyclops Works, Sheffield ... ... (E) Jan. 1898
Hartness, Charles, 2, Summerhill East, Sunderland ... ... (E) Dec. 1898
Harvey, Herbert Buchanan, 38 Grainger Street West, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1896 / Member, Oct. 1898
Harvey, James Andrew, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (E) Feb. 1899
Harvey, John W. J., 1, Richmond Villa, Chertsey Road, Redland, Bristol ... ... (E) Feb. 1889
Haussman, B., 39A, Gracechurch Street, London, E.C. ... ... (E) Feb. 1899
Headlam, Robert, New Park Terrace, Hartburn Lane, Stockton-on-Tees ... ... (E) Nov. 1886
Heaviside, Arthur West, 7, Grafton Road, Whitley Bay, Northumberland ... ... (E E) Oct. 1896
Heck, John H., Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (S SUR) Nov. 1885
Henderson, Alex., c/o Messrs. Empreza, Nacional, De. Nav. D'Vapor, Lisbon ... ... (E) April 1893
Henderson, A. M., 3, Greatham Terrace, West Hartlepool ... (E) Nov. 1890
Henderson, George, 54, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Henderson, John, 96 Plasturton Avenue, Canton, Cardiff ... ... (N A) June 1896
Henry, William P., Cragside, St. Aidan's Road, South Shields ... (E) April 1897
Henshall, Samuel, 7, Lennox Street, Middlesbrough (S) { Graduate, May 1885 / Member, Jan. 1894
Hepburn, Alfred, Northumberland Forge, Wallsend-on-Tyne ... (F M) Dec. 1890
Hepple, William, Messrs. Hepple & Co., Engineers, South Shields ... ... (E & S) Oct. 1885

ELECTED.

Hepple, William Thos., Messrs. Hepple & Co., Engineers, Wapping Street, South Shields ... ... (E) Dec. 1893
Hesketh, Thomas, Bryn Tirion, Richmond Road, Cardiff ... ...(SUR) April 1896
Hetherington, William, 27, Co-operative Terrace, Sunderland ... (S) Dec. 1899
Higgins, C. F., c/o Messrs. T. Richardson & Sons, Ltd., Hartlepool ... ... (E E) Feb. 1898
Hildrey, A. J., 11, Newcastle Road, Sunderland ... ... (S) Nov. 1884
Hill, Maxwell, 7, The Side, Newcastle-upon-Tyne ... ... (N A) Nov. 1884
Hinchliffe, Robert, 25, Hawthorn Street, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1893; Member, Oct. 1898
Hindson, William Forster, 11, St. Oswin's Avenue, Cullercoats... ... ... (E) { Graduate, Nov. 1891; Member, Nov. 1892
Hirst, Richard, 25, Brougham Terrace, West Hartlepool ... (E SUR) Nov. 1885
Hobbs, Arthur, c/o Messrs. Ferranti, Ltd., Hollingwood, Oldham ... ... (E) { Graduate, Nov. 1897; Member, Oct. 1898
Hodge, Rowland F. W., c/o Messrs. The Northumberland Shipbuilding Co., Limited, Northumberland Shipyard, Howdon-on-Tyne ... ... (S) Dec. 1890
Hodgson, Rich., Bowness, Gordon Street, Workington ... ... (S) Dec. 1896
Hogarth, G. V., 32, Water Lane, Maryland Point, London, E.C. (S) May 1900
Hogg, Archibald, Netherleigh, Beach Avenue, Whitley Bay, Northumberland ... ... (S) Jan. 1897
Hogg, James, 8, Lovaine Terrace, North Shields ... ... (B F) Nov. 1889
Hök, Wilhelm, Deptford Shipyard, Sunderland ... ... (S) Oct. 1886
Holgate, Charles H., School Close Works, Leeds ... ... (E) Feb. 1895
Hollis, Henry E., 40 Union Street, Glasgow ... ... (I & S M) Feb. 1885
Holmes, John H., Portland Road, Newcastle-upon-Tyne ... ... (E E) Jan. 1888
Homji, A. C. N., c/o Messrs. Lakhmidas Khimji S. & W. Co., Limited, Fergusson Road, Bombay, India ... ... (E) Nov. 1884
Hooper, Ernest, 24, Whitehall Terrace, Hylton Road, Sunderland (E) Nov. 1885
Hougland, Even, Lloyd's Surveyor, Bergen, Norway ... ... (E) Dec. 1896
Houston, John, 7 Thornhill Crescent, Sunderland ... ... (E) Nov. 1894
Hughes, Thos. Charles, 3, Summerhill Street, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1893; Member, Nov. 1897
Hunter, George B., Messrs. C. S. Swan, Hunter & Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
Hunter, George Ernest, The Willows, Jesmond, Newcastle-upon-Tyne ... ... (S) { Graduate, Feb. 1898; Member, Nov. 1899
Hunter, Joseph Gilbert, 29, Regent Quay, Aberdeen ... (SUR) Feb. 1900
Hunter, J. W., 10, Princess Street, Stockton Road, Sunderland ... (E) May 1885
Hunter, Summers, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1885
Hutchinson, C. W., 6, Park Parade, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Hutchinson, Wesley, B.A., 6, Park Parade, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Oct. 1891
Hutchison, J., Board of Trade Offices, Middlesbrough ... ...(SUR) Dec. 1891
Hyslop, Alfred M., c/o Messrs. Boothroyd & Co., Akenside Street, Bootle, Liverpool ... ... (E) Mar. 1900

I.

Inglis, John, c/o Messrs. Hawthorn & Co., Leith ... ... (S) April 1887

ELECTED.

Inglis, John, Pointhouse Shipyard, Partick, Glasgow ... (E & S) Oct. 1886
Irwin, J. H., Sunderland Engine Works, South Docks, Sunderland (E) Nov. 1884
Ives, Bernard, c/o Messrs. Lloyd's Register of Shipping, 8, White Lion Court, Cornhill, London, E.C. ... ... (S) Feb. 1898

J.

Jack, Charles Kellie, c/o Messrs. Ropner & Sons, Shipbuilders, Stockton-on-Tees ... ... (S) Nov. 1897
Jack, William C., c/o Messrs. The Hong Kong & Whampoa Dock Co., Limited, Hong Kong, China ... ... (E) Nov. 1894
Jackson, Albert S., 3, Mount Stuart Square, Cardiff ... ... (E) Mar. 1896
Jackson, William S., Messrs. Gourlay Bros. & Co., Camperdown Shipyard, Dundee... ... ... (S) April 1891
James, M. C., 6, Park Terrace, Gateshead-on-Tyne ... ... (S) Nov. 1884
Jennings, Frederick, c/o Messrs. Sturtevant Engineering Co., Limited, 75 Queen Victoria Street, London, E.C. ... ... (E) Feb. 1898
Jewitt, Charles Wm., West Park View, Stanhope Road, South Shields ... ... (E & S) Nov. 1897
Jobling, W. J., 1, Akenside Hill, Newcastle-upon-Tyne ... (E & S O) Nov. 1884
Jobson, Robert, Jun., Clifton Avenue, West Hartlepool ... ... (S) Feb. 1898
Johnson, Alexander A., Bank Chambers, Sandhill, Newcastle-upon-Tyne ... ... (E) Feb. 1893
Johnson, Johan, 7, Vestra Hamngaten, Gothenburg, Sweden ... (S) May 1885
Johnson, T. Allan, Dry Docks, Passage West, Cork ... ... (S) Nov. 1884
Johnstone, William, Lloyd's Register of Shipping, 56, John Street, Sunderland ... ...(SUR) Nov. 1884
Jones, George, c/o Messrs. W. Gray & Co., Shipyard, West Hartlepool ... ... (S) Oct. 1888
Jubb, Arthur, 29, Coldwell Terrace, Felling-on-Tyne ... ... (E) Jan. 1900

K.

Kaneda, Wasaburo ... ... (SUR) Nov. 1897
Keene, H. R., Lloyd's Register of Shipping, Ouest Quai, 28, Katendyk, Antwerp ... ... (E) { Graduate, May 1885; Member, April 1887 }
Kendall, Stonard O., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ...(SUR) Mar. 1891
Kennedy, William, 14, Gladstone Street, Hartlepool ... ... (E) April 1900
Kerfoot, James, 45, Rue de Grand Chila, Zurenberg, Antwerp ... (E) Oct. 1892
King, John, 16, Lefroy Street, Newcastle-upon-Tyne (S) { Graduate, Dec. 1890; Member, Oct. 1892 }
Kirby, John Storne, 19, Lily Avenue, Jesmond, Newcastle-upon-Tyne... ... ... (E) Mar. 1899
Kirkaldy, John, 21, Ground Floor, Leadenhall House, 101, Leadenhall Street, London, E.C. ... ... (E) Nov. 1885
Kitching, J. F., Clifton Avenue, West Hartlepool ... ... (E) Nov. 1890
Kyle, Norman M. W., 26, Sandhill, Newcastle-upon-Tyne ... (E) Nov. 1898

L.

Lace, Basil T., Lyncombe Rise, Bath ... ... (E) { Graduate, Nov. 1895; Member, Nov. 1897 }

ELECTED.

Laing, Andrew, c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (E) Oct. 1892
Laing, Arthur, Deptford Shipyard, Sunderland ... ... (S) Nov. 1884
Laing, Hugh, Deptford Shipyard, Sunderland ... ... (N A) April 1897
Laing, John, c/o Messrs. R. & W. Hawthorn, Leslie, & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Landreth, Cowen, 34, Simonside Terrace, Newcastle-upon-Tyne ... (E) Mar. 1896
Lang, William Veysey, c/o Messrs. Smith's Dry Dock Co., North Shields ... ... (E) Nov. 1897
Lange, E., 18, Walbrook, London, E.C. ... ... (E) Mar. 1900
Larkin, James, Tyne View, East Jarrow-on-Tyne ... ... (E) Nov. 1884
Leathard, Thomas Surtees, 9, Otto Terrace, Sunderland ... ...(SUR) April 1899
Lewins, Frank, 23, Meldon Terrace, Heaton, Newcastle-upon-Tyne (E) Dec. 1895
Lewis, R. A., Newburn Steel Works, Newburn-on-Tyne ... ... (E) Nov. 1884
Liddell, J., c/o Messrs. Denny & Co., Engine Works, Dumbarton (E) Nov. 1884
Lie, Gotfred, Det Bergenske Dampskibsselskab, Bergen ... ... (E) Jan. 1895
Lindfors, Hugo, Surveyor to Lloyd's Register of Shipping, 16, Alexandersgatan, Helsingfors, Finland ... ... (SUR) May 1889
Lineham, Wilfrid J., Jesmond, Leyland Road, Lee, London, S.E. (E) Oct. 1890
Lishman, John J., Jun., 16, Lovaine Place, North Shields ... ... (E) { Graduate, Dec. 1892; Member, May 1900 }
Littleboy, Chas. Wm., The Woodlands, Saltburn-by-the-Sea ... (S) Oct. 1887
Littledale, John W. E., 10 Huntingdon Place, Tynemouth ... (E) May 1896
Livingston, Thos. L., Dunedin House, Jarrow-on-Tyne ... ... (S) Nov. 1884
Lohmeyer, H., 53, Crown Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Long, A. E., 124, Albert Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Lowdon, David, Messrs. The Barry Graving Dock and Engineering Co., Limited, Barry Dock, near Cardiff ... ... (E) May 1894
Lowdon, John, Messrs. The Barry Graving Dock and Engineering Co., Limited, Barry Dock, near Cardiff ... ... (E) Dec. 1891
Lumley, William, 2, Claremont, Gateshead-on-Tyne... (E) { Graduate, June 1896; Member, Oct. 1898 }

M.

MacColl, Hector, Bloomfield, Belfast ... ... (E) Dec. 1890
MacColl, Hugo, Wreath Quay Engineering Works, Sunderland ... (E) Nov. 1896
Maccoy, John, Springfield, Gateshead-on-Tyne ... ... (E) Feb. 1886
Macdonald, Charles, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ...(SUR) Feb. 1898
MacDonald, David R., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne (S) Nov. 1891
Macdonald, John C., c/o Messrs. Northumberland Engine Works, Wallsend-on-Tyne... ... ... (E) Nov. 1899
Mace, W., 253, Albert Road, Jarrow-on-Tyne ... ... (E) Jan. 1886
MacHaffie, John, 635, Terrace Place, Schenectady, New York, U.S.A. (E) Dec. 1885
Macgregor, W. L., Board of Trade Surveyors' Offices, Blyth ...(SUR) Mar. 1899
Mackay, William, 15, Camperdown Road, Scotstoun, Renfrewshire ... ... (S) Mar. 1892
Mail, M., Jun., 8, Ashbrook Terrace, Sunderland ... ... (E) Nov. 1897
Mair, James, Wh.Sc., 1, Bedford Terrace, North Shields ... ... (E) Oct. 1894
Manaira, Guiseppe, 4, Salita S Gerslamo, Genoa, Italy ... (E & N A) Nov. 1893

ELECTED.

Marr, James, c/o Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland ... ... (S) Nov. 1884
Marsden, John H. Wade, 9, Lovaine Crescent, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Marshall, F. C., Akenside Lodge, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Marshall, Frank T., Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Graduate, Jan. 1885; Member, Oct. 1888
Marshall, R. J., 51, Larkspur Terrace, Jesmond, Newcastle-upon-Tyne... ... ... (E) Mar. 1887
Maslen, Frank E., The Priory, Hampstead Heath, London, N.W. ... ... (E) Graduate, Nov. 1891; Member, May 1898
Mason, George F., Lloyds' Bank Buildings, Mount Stuart Square, Cardiff ... ... (E) Oct. 1895
Mather, Charles, 2, St. George's Terrace, Newcastle-upon-Tyne... (SUR) Oct. 1888
Mather, Clifford Basil, Lesbury House, Lesbury, R.S.O. (N A) Graduate, Oct. 1892; Member, Oct. 1898
Mather, Thomas Brewer, 13, Park Avenue, Whitley Bay, Northumberland ... ... (C E) Nov. 1898
Matheson, William, c/o Messrs. R. & W. Hawthorn, Leslie & Co., Hebburn-on-Tyne... ... ... (S) Dec. 1889
Mathieson, Donald, 30, Jackson Street, Sunderland ... ... (E) Nov. 1898
Matthews, A., c/o Messrs. Blyth Shipbuilding Co., Blyth... ... (S) Nov. 1884
Matthews, Jas., c/o Messrs. R. & W. Hawthorn, Leslie & Co., Forth Banks, Newcastle-upon-Tyne ... ... (E) Oct. 1886
Maxwell, Thomas, 15, Ashfield Terrace, East, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Maxwell, William Ward, B.Sc., Messrs. H. Charlton & Co., Engineers, Gateshead-on-Tyne ... ... (E) Dec. 1896
McBride, William, Beaconsfield Square, Hartlepool ... ... (E) Dec. 1894
McGillivray, Peter, 14, Normanton Terrace, Newcastle-upon-Tyne (E) Nov. 1899
McGlashan, Arch., Beechcroft, Clifton Avenue, West Hartlepool (S) Nov. 1885
McGregor, Duncan, 5, Bishopton Street, Sunderland ... ... (S) Dec. 1899
McIlvenna, J. G., c/o Messrs. The Tyne Pontoons and Dry Docks Co., Wallsend-on-Tyne ... ... (S) Nov. 1884
McKechnie, James, Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) April 1896
McKenna, Francis, c/o Messrs. E. F. Wailes & Co., 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... (E) Graduate, Dec. 1890; Member, Dec. 1896
McLaren, Robert M., 10, Grove Street, Newcastle-upon-Tyne ... (S) Nov. 1893
McLaren, William, 16, Rock Park, Rock Ferry, Cheshire ... ... (E) Oct. 1894
McLean, John H. K., Abey House, Plotina Terrace, South Shields (S) Mar. 1897
McNeil, Thomas Young, Ship Drawing Office, Messrs. The Clydebank Engineering and Shipbuilding Co., Glasgow ... ... (S) Oct. 1895
Meagher, H. L., 4, Linden Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1896
Mechan, Henry, Scotstoun Ironworks, Scotstoun, Glasgow ... (E) May 1898
Meldrum, Michael, Humbledon View, Sunderland ... ... (E) Dec. 1893
Mellanby, Alex. Lawson, B.Sc., Fernleigh, Grange Road, West Hartlepool... ... ... (E) Graduate, Dec. 1894; Member, Oct. 1896
Messenger, Thomas, "Greeba," Mathian Road, East Molesey, Surrey ... ... (E) Mar. 1887
Metcalf, Thos., 18, John Street, Sunderland... ... (S) Graduate, May 1885; Member, Nov. 1893

ELECTED.

Metcalfe, C. S., 24, Croft Avenue, Sunderland ... ... (E) Nov. 1884
Meuwissen, J., 18, Esplanade, Whitley Bay, Northumberland ... (E) Nov. 1899
Micheli, Pietro, Jun., Via Sottoripu, No. 1, piano nobile, Genoa, Italy ... ... (E & N A) Oct. 1888
Middlemass, Thomas, 3, Albert Place, Norton Road, Stockton-on-Tees... ... ... (S) Oct. 1889
Middleton, H., 20, Lynnwood Avenue, Newcastle-upon-Tyne (I & S M) Jan. 1893
Middleton, Robert Alexander, c/o Messrs. Vickers, Sons & Maxim, Ltd., Naval Construction Works, Barrow-in-Furness ... (N A) Oct. 1892
Millar, Thos., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Mills, John, 70, Ledard Street, Langside, Glasgow ... ... (E) Feb. 1888
Milton, J. T., Lloyd's Register of Shipping, 2, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Nov. 1886
Moffatt, James, 7, Murray's Terrace, Belfast, Ireland (E) { Graduate, Dec. 1889; Member, Oct. 1892 }
Moffatt, William Graham, 44, Lennox Avenue, Scotstoun, Glasgow (E) Mar. 1899
Moffitt, George, c/o Messrs. The Blyth Shipbuilding Co., Blyth ... (S) Oct. 1888
Moffoot, Alexander, 32, Eldon Street, Chester Road, Sunderland.. (S) Mar. 1898
Moncrieff, John M., 2, St. Nicholas' Buildings, Newcastle-upon-Tyne... ... ... (C E) Dec. 1899
Moody, Thomas V., c/o Messrs. Scott Bros., 46, Sandhill, Newcastle-upon-Tyne ... ... (E) Dec. 1887
Moore, Frederick, c/o Messrs. Wilson, Sons & Co., Ltd., Bahia ... (E) Oct. 1890
Moore, Wm. Henry, c/o Messrs. Workman, Clark, & Co., Engine Works, Spencer Basin, Belfast ... ... (E) Nov. 1897
Morgan, W. H., 22, Rochdale Street, Wallsend-on-Tyne ... ... (E) Nov. 1884
Morison, D. B., Hartlepool Engine Works, Hartlepool ... ... (E) Feb. 1885
Mörk, Peter, 31, Holsteinsgude, Copenhagen ... ... (E) Nov. 1884
Moroney, E. F., 11, Shields Road, East, Newcastle-upon-Tyne ... ... (E) { Graduate, Feb. 1892; Member, Nov. 1899 }
Morrison, Robt., Highfield, St. Aidan's Road, South Shields ... (E) Nov. 1886
Morrison, William, Lloyd's Register of Shipping, Maritime Buildings, Dundee ... ... (E SUR) Oct. 1890
Morton, David ... ... (S) Feb. 1898
Morton, Richard Fraser, Lloyd's Register of Shipping, Buckingham Chambers, St. James Street, Sheffield ... (E SUR) Oct. 1890
Mould, Francis H., 36, Salter's Road, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Feb. 1892; Member, Jan. 1897 }
Mountain, William Chas., Messrs. Ernest Scott, Mountain, & Co., Close, Newcastle-upon-Tyne ... ... (E E) Feb. 1889
Muir, Alfred Edward, Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland ... ... (S) Mar. 1893
Muir, Chas. M., 32, William Street, Newcastle Road, Sunderland... (S) May 1899
Muir, Robert, 11, Clarence Crescent, Whitley Bay, Northumberland ... ...(SUR) Oct. 1886
Muir, Robert Home, 1, Lovaine Crescent, Newcastle-upon-Tyne ... (S) Oct. 1892
Munck, Ove. Holger, c/o Messrs. Burmeister & Wain, Shipbuilders, Copenhagen, Denmark ... ... (S) Feb. 1899
Musgrave, Evers, 8, Lastingham Terrace, Frilford, York (E) { Graduate, Nov. 1891; Member, Oct. 1895 }
Myles, David, Northumberland Engine Works, Wallsend-on-Tyne (E) Nov. 1884

ELECTED.

N.

Nastoupil, John, Chief Engineer, Austro-Hungarian Navy, Marine Casino, Pola, Austria ... ... (E) Nov. 1890
Neill, William Reid, 15, Salem Hill South, Sunderland ... ... (E) Dec. 1897
Nevins, William, 1, Hall Royd, Shipley, Yorkshire ... ... (E) Mar. 1894
Nevison, Thomas C., c/o Messrs. Crosby, Magee, & Co., West Hartlepool ... ... (E) April 1900
Nichol, Bryce G., Eldon Street, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1891; Member, May 1898
Nicholls, H. E., 25, Churchill Street, Sunderland ... ... (E) Nov. 1893
Nichols, Walter W., 30, Denmark Street, Gateshead-on-Tyne ... (E) May 1895
Nicholson, John S., North View, Mowbray Road, Westoe, South Shields ... ... (E) Nov. 1893
Nicholson, Joseph Cook, Collingwood Street, Newcastle-upon-Tyne (E) Feb. 1897
Nicholson, Thos. Head, 90, Rye Hill, Newcastle-upon-Tyne ... (E) Nov. 1897
Nicol, John M., 15, Linskill Terrace, North Shields ... ... (E) Nov. 1884
Nicolson, G. C., H.M.S. "Rambler," North America and West India Stations ... ... (E) { Graduate, Oct. 1885; Member, Oct. 1888
Niven, William A., 6, Jackson Street, Walker-on-Tyne ... ... (E) Nov. 1898
Noble, George, 8, Latimer Street, Tynemouth ... ... (E) May 1893
Noble, Harry, Northern Machine Tool Works, Brewery Lane, Felling-on-Tyne ... ... (E) Nov. 1888
Nodder, Joseph, Ash Lea, Crabtree, Sheffield ... ... (F M) May 1893
Norman, W. S., Orchard House, Whitby, near Chester ... ... (E) Nov. 1884
Norton, Harold P., Engineer Corps U.S. Navy, Washington, U.S.A. ... ... (E) Oct. 1890
Noton, F. R., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ... (S) Nov. 1884
Nunes, Enrique E., 1898 Calle Virreyes, Belgrano, Buenos Ayres (E) April 1891

O.

O'Halloran, Timothy, c/o Messrs. Booth & O'Halloran, 13, Rue du Bresil, Antwerp, Belgium... ... ... (E) Jan. 1895
O'Neil, J. J., 2, Erith Terrace, Sunderland ... ... (E) Nov. 1884
Ord, Godfrey C., The Esplanade, Sunderland ... ... (E E) Jan. 1897
Orde, E. L., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne ... ... (E) Oct. 1887
Orlando, Chev. Giuseppe, Cantiere Navale, Fratelli Orlando, Leghorn ... ... (N A) Jan. 1893
Ormonde, John Grey, 35, Percy Gardens, Tynemouth ... ... (E) Nov. 1897
Orr, John, B.Sc., Lecturer in Engineering, South African School of Mines, Kimberley, S.A. ... ... (E) Mar. 1897
Orr, Reginald, Kent Villa, Roxborough Park, Harrow-on-the-Hill, Middlesex ... ... (E) { Graduate, Mar. 1890; Member, Oct. 1892
Ortton, Alfred R., 27, General Graham Street, Chester Road, Sunderland ... ... (E) Nov. 1898
Owens, J. Switzer, B.A., Carleys Bridge House, Enniscorthy, Ireland ... ... (E) Oct. 1898
Oxley, G., 51, Norman Terrace, Howdon-on-Tyne ... ... (S) Nov. 1884
Oxton, Walter, 96, Blackpool Street, Burton-on-Trent (E) { Graduate, Dec. 1890; Member, May 1894

ELECTED.

P.

Parker, James H., Gladstone Street, Hartlepool ... ... (E) April 1900
Parr, Joseph E., 21, Zion Terrace, Newcastle Road, Sunderland... ... ... (S) Graduate Nov. 1898; Member, Dec. 1899
Parsons, Hon. Charles A., Turbinia Works, Wallsend-on-Tyne ... (E E) Dec. 1887
Parsons, Harry F., c/o P. Brotherhood, Esq., Belvedere Road, Westminster Bridge, London, S.E. ... ... (E) Dec. 1890
Pascoe, J. R., Tyrmont, Woodford Green, Essex (*Life Member*) ... (S) Dec. 1889
Patterson, Jas., c/o Messrs. Caldwell & Co., Limited, Elliot Street, Glasgow ... ... (E) Nov. 1884
Pattison, Jos., Bute Docks, Cardiff ... ... (E) Nov. 1884
Paulin, William J., 148, Portland Road, Newcastle-upon-Tyne ... (E) April 1897
Paulson, John, c/o Messrs. William Cramp & Sons, Shipbuilders, Philadelphia, Pa., U.S.A.... ... ... (S) Feb. 1886
Paxton, John F., 52, Walker Terrace North, Gateshead ... ... (E) May, 1899
Payne, Henry Fernie, 15, Willowbank Road, Devonshire Park, Birkenhead ... ... (E) Dec. 1895
Pearson, James T., 10, Beech Grove Road, Newcastle-upon-Tyne ... ... Graduate, Nov. 1893; Member, Dec. 1897
Penney, R. H., Board of Trade Offices, 79, Mark Lane, London, E.C. ... ... (S SUR) Nov. 1884
Pepper, W., 9, West Villas, Oxbridge Lane, Stockton-on-Tees ... (E) Nov. 1888
Perrett, Jos. Richard, West View, Durham Road, Gateshead-on-Tyne ... ... (N A) Nov. 1897
Pescod, Joseph Hind, 1, Railway Street, Jarrow-on-Tyne (S) Graduate, Feb. 1898; Member, Jan. 1900
Petersen, John L., Havelock House, Victoria Road, West Hartlepool (SUR) Oct. 1888
Petree, James, Lloyd's Register of Shipping, 12, Oriel Chambers, Water Street, Liverpool ... ... (N A SUR) Oct. 1885
Petterson, Carl Edwin, 7, Vestra Hamngaten, Gothenburg, Sweden (E) Oct. 1891
Philipson, Roland, Tynemouth... ... ... (E) Dec. 1884
Phorson, P., Glen Lea, Roker, Sunderland ... ... (S) Nov. 1884
Piaud, Leon, 8, Boulevard de la Republique, Chatou, Paris ... (N A) Nov. 1888
Pierce, Robert Cecil, 114, Queen's Road, Bayswater, London, W. ... ... (E E) Graduate Dec. 1898; Member Dec. 1899
Pirrie, Norman, c/o Messrs. Babcock, Wilcox, & Co., Limited, 147, Queen Victoria Street, London, E.C. ... ... (E) Nov. 1897
Pitt, Frederick William, 552, Chester Road, Old Trafford, Manchester, S.W. ... ... (E SUR) Oct. 1890
Poli, Rodolfo, Chioggia, Italy ... ... (N A) Jan. 1890
Pollard, T., 248, Willington Road, Eccles, Manchester ... ... (E) Dec. 1896
Pollock, Walter, c/o Messrs. Jas. Pollock, Sons, & Co., 22, Billiter Street, London, E.C. ... ... (N A) April 1900
Potts, Cuthbert Ivan, 4, Sidney Road, Bootle, Liverpool ... ... (E) Oct. 1895
Potts, Robert L., Hill House, Deptford, Sunderland ... ... (S) Oct. 1888
Powell, James Richard, Royal Stuart Buildings, Cardiff ... ... (C E) May 1894
Price, John, 6, Osborne Villas, Jesmond, Newcastle-upon-Tyne ... (S) Nov. 1884
Pringle, Alfred, 10, Somerset Terrace, Walker-on-Tyne (S) Graduate, Dec. 1891; Member, Jan. 1894
Pringle, James G., 10, Somerset Terrace, Walker-on-Tyne... ... (S) Oct. 1892
Purdon, Andrew S., Messrs. Irvine's Shipbuilding and Dry Docks Co., Limited, West Hartlepool .. .. (S) Oct. 1892

ELECTED.

Purvis, Andrew Alex., 3, Victoria Avenue, Whitley Bay, Northumberland ... ... (E) Dec. 1899
Purvis, Fred. W., c/o Messrs. Sir W. Gray & Co., Central Shipyard, West Hartlepool ... ... (S) April 1893
Putnam, T., Darlington Forge, Darlington ... ... (F M) Nov. 1884

Q.

Quicke, Herbert John, c/o Messrs. Harfield & Co., Blaydon Ironworks, Blaydon-on-Tyne ... ... (E) Feb. 1891

R.

Ramage, J. T., St. Aubyn's, Bonnington, Edinburgh ... ... (E) April 1887
Ramage, John Anderson, 74, Glen Terrace, Hebburn-on-Tyne ... (S) Oct. 1892
Readhead, Jas., Westoe Hall, South Shields ... ... (S) Nov. 1884
Readhead, John, 4, Salisbury Place, South Shields... ... ... (E) Mar. 1886
Readhead, R., South Garth, Westoe Village, South Shields ... (E) Nov. 1884
Readhead, W. B., Beach View, South Shields ... ... (S) Nov. 1886
Reavell, W., Ranleigh Works, Ipswich ... ... (E) { Graduate, April 1885; Member, Oct. 1887 }
Reed, James, Messrs. Palmer's Shipbuilding and Iron Co., Ltd., Jarrow-on-Tyne ... ... (S) Dec. 1897
Reed, Joseph, Angerton House, North Shields ... ... (E) Oct. 1889
Reed, J. W., c/o Messrs. Palmer's Shipbuilding and Iron Co., Limited, Engine Works Department, Jarrow-on-Tyne ... (E) Nov. 1884
Reed, Richard, c/o Messrs. Sir Raylton Dixon & Co., Cleveland Dockyard, Middlesbrough ... ... (S) Oct. 1894
Reid, John Robert, 88, Leslie Terrace, Aberdeen ... ... (E) Nov. 1898
Reid, William, c/o Messrs. Wm. Reid & Co., 112, Fenchurch Street, London, E.C. ... ... (E) Dec. 1899
Rennoldson, C., Messrs. J. P. Rennoldson & Sons, South Shields (S) Jan. 1886
Rennoldson, Jos. M., Messrs. J. P. Rennoldson & Sons, South Shields (S) Feb. 1886
Renton, John, 1, Akenside Hill, Newcastle-upon-Tyne ... (M SUR) April 1895
Reynolds, Charles H., c/o Messrs. Burmeister & Wain, Shipbuilders, Copenhagen, Denmark ... ... (S) Mar. 1889
Reynolds, W. G., 26, Sandhill, Newcastle-upon-Tyne ... ... (E) Oct. 1886
Richardson, Sir Thomas, B.A., M.P., Hartlepool Engine Works, Hartlepool ... ... (E) April 1888
Richardson, Wigham, Neptune Works, Walker-on-Tyne ... ... (S) Nov. 1884
Rickaby, A. A., Bloomfield Engine Works, Sunderland ... ... (E) Mar. 1888
Ridley, J. H., Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Riley, J. H., Messrs. Riley Bros., Stockton-on-Tees ... ... (B B) May 1893
Ritson, M., Lloyd's Register of Shipping, c/o F. Schiaffino, Esq., Piazza S Giorgis, 32, Scalaprinia. Genoa ... (E SUR) Nov. 1884
Ritson, S. M., 7, Dogo Street, Cardiff ... ... (E) { Graduate, Nov. 1887; Member, Nov. 1893 }
Robinson, Charles O., Ingleside, North Shields ... (E) { Graduate, Dec. 1893; Member, Nov. 1899 }
Robinson, William, Delaval House, 3, Broxbourne Terrace, Sunderland ... ... (E) { Graduate, May 1885; Member, April 1888 }
Robson, David M., 10, West Park Terrace, South Shields... ... (E) Nov. 1899

ELECTED.

Robson, George, 9, Wellington Terrace, South Shields ... ... (E) Oct. 1889
Robson, George, 140, Aurelian Terrace, South Shields ... ... (E) Feb. 1896
Robson, John H., 16, Sunbury Avenue, Newcastle-upon-Tyne ... (E) Nov. 1885
Robson, J. M., 4, Abbey Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1884
Robson, M., 20, Tavistock Place, Sunderland ... ... (S) Nov. 1884
Robson, Nathaniel E., 15, Laburnum Avenue, Wallsend-on-Tyne... ... ... (E) { Graduate, Dec. 1894; Member, Nov. 1897
Roger, Robert, Stockton Iron Foundry, West Row, Stockton-on-Tees (E) Nov. 1888
Rogers, Herbert M., Redcliffe, Durham Avenue, Bromley, Kent (SUR) April 1889
Rolf, George, 8, Bentinck Crescent, Newcastle-upon-Tyne ... (E E) May 1892
Rolland, Alexander, Villa Ruzic, Susak, Fiume, Hungary... ... (E) Mar. 1892
Ropner, Robert, Jun., Stockton-on-Tees ... ... (S) Feb. 1886
Rosenthal, James H., Woodville, 97, Eltham Road, Lee, Kent ... (E) Dec. 1896
Roseti, Capt. S. G., 353, Santiago del Estavo, Buenos Ayres, Argentine Republic ... ... (N A) June 1896
Ross, Charles, c/o Messrs. Smith's Dock Co., Ltd., High Docks, South Shields ... ... (E) Jan. 1898
Ross, William, 20, Meadow Side, Dundee ... ... (E) May 1893
Rosser, W. D., Bute Dry Dock, Roath Basin, Cardiff ... ... (S) Nov. 1893
Rowan, Jas., 231, Elliott Street, Glasgow ... ... (E) Nov. 1886
Rowell, G. W., 22, Armstrong Road, New Benwell, Newcastle-upon-Tyne ... ... (E) Feb. 1885
Rowell, H. B., Cleugh Brae, Jesmond East Park, Newcastle-upon-Tyne (*Life Member*) ... ... (S) Nov. 1884
Rusden, L., 14, Sanderson Road, Jesmond, Newcastle-upon-Tyne (E) Nov. 1884
Russell, F. Herbert, Scotia Engine Works, Sunderland ... ... (E) Oct. 1891
Rutherford, G., Messrs. Mercantile Pontoon Co., Roath Dock, Cardiff (S) Oct. 1886
Rutherford, J. T., 39, Osborne Road, Stroud Green Road, London, N. ... ... (E) { Graduate, Jan. 1886; Member, Nov. 1893
Rutherford, Robert T., 34, Denmark Street, Gateshead-on-Tyne ... (E) Nov. 1899
Ryder, C. L., London Salvage Association, Mount Stuart Square, Cardiff ... ... (E) Oct. 1886

S.

Salmon, P., 5, The Oaks West, Sunderland ... ... (E SUR) Nov. 1884
Sambidge, James, c/o Messrs. J. H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E E) Nov. 1891
Sandeman, John Watt, 2, St. Nicholas' Buildings, Newcastle-upon-Tyne... ... ... (E) Oct. 1891
Sanderson, Henry Thomas Barron, Messrs. Sanderson & Co., High Quay, Blyth ... ... (E) Oct. 1891
Sanderson, J., 31, Park Road, Jarrow-on-Tyne ... ... (S) Nov. 1884
Sandison, M., 3, Devonshire Terrace, Newcastle-upon-Tyne ... (E) Dec. 1884
Sawyer, John, c/o Messrs. Thos. Wilson, Sons, & Co., Hull ... (E) Oct. 1886
Schaeffer, A. G., 16, Lombard Street, Newcastle-upon-Tyne ... (E) Nov. 1884
Scott, Ernest, Close Engine Works, Newcastle-upon-Tyne ... (E E) Nov. 1884
Scott, James, c/o Messrs. Consett Iron Co., Blackhill, Co. Durham (E) Oct. 1892
Scott, Joseph, 49, Leazes Terrace, Newcastle-upon-Tyne (E) { Graduate, Dec. 1891; Member, Oct. 1898
Scott, Joseph R., 9, Queen Street, Newcastle-upon-Tyne ... ... (E) Oct. 1887
Scott, Walter, 30, Bellevue Terrace, Ayr ... ... (N A) Mar. 1897

ELECTED

Scott, William, c/o Messrs. R. & W. Hawthorn, Leslie & Co., St. Peter's, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Scott, William, Lyndhurst, 19, Plasturton Avenue, Cardiff ... (E) June 1896
Scurfield, George G., 98, Aglionby Street, Carlisle ... ... (E) Mar. 1897
Seabury, Edward, Burnt Mill House, Harlow, Essex ... ... (E) Mar. 1886
Seaman, C. J., 134, High Street, North Stockton-on-Tees ... ... (E) Jan. 1889
Seaton, Albert Edward, Messrs. Earle's Shipbuilding Co., Hull ... (E) Jan. 1891
See, Horace, 1, Broadway, New York City, U.S.A. ... ... (E) May 1896
Sergent, William John, 53, Sandringham Road, Waterloo, near Liverpool ... ... (E) Oct. 1898
Shand, H., 64, Queens Road, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Sharp, A. E., c/o Messrs. The Peninsular and Oriental Steam Navigation Co., 122, Leadenhall Street, London ... ... (E) Nov. 1884
Sharp, Mark, 144, Albert Road, Jarrow-on-Tyne ... ... (E) Dec. 1889
Shaw, Jas., 26, Sandhill, Newcastle-upon-Tyne ... ... (M SUR) Jan. 1885
Sheriff, Thomas, c/o Messrs. Robert Mackill & Co., 53, Bothwell Street, Glasgow ... ... (E) April 1890
Short, John Gill, 57, John Street, Sunderland ... ... (NA) Feb. 1899
Short, Jos., 13, John Street, Sunderland ... ... (S) Nov. 1884
Short, Thomas S., c/o Messrs. Short Brothers, Pallion, Sunderland ... ... (S) { Graduate, Oct. 1892; Member, May 1899 }
Shotton, John W., 32, Mount Stuart Square, Cardiff ... ... (SUR) Nov. 1886
Shute, A. E., 12, Clyde View, Partick, Glasgow ... ... (E) Dec. 1892
Sibson, T. ... ... (E) Dec. 1898
Sibun, William, Lloyd's Register of Shipping, Bute Docks, Cardiff ... ... (SUR) Mar. 1896
Simpson, Kenneth, c/o Messrs. John Brown & Co., Clydebank Shipbuilding Yard, Glasgow ... ... (S) { Graduate, Dec. 1893; Member, Oct. 1895 }
Sinclair, R., c/o Messrs. J. Wildridge & Sinclair, Consulting Engineers, 97, Pitt Street, Sydney, N.S.W., Australia ... (C E) Nov. 1884
Sinton, John K., 26, Sandhill, Newcastle-upon-Tyne ... ... (E) Nov. 1885
Sisson, Wm., Gloucester ... ... (E & N A) Oct. 1888
Sitwell, John K., 24, Archbold Terrace, Newcastle-upon-Tyne... ... ... (E) { Graduate, Nov. 1896; Member, Oct. 1898 }
Sivewright, G. W., 5, Radcliffe Terrace, Hartlepool ... ... (S) Nov. 1886
Skinner, Leslie, Ravensbourne Terrace, South Shields (S) { Graduate, Dec. 1886; Member, Oct. 1891 }
Smith, C. E., Cowesby, Clifton Avenue, West Hartlepool ... (E) Nov. 1888
Smith, Eustace, Guildhall, Newcastle-upon-Tyne ... ... (S) Nov. 1884
Smith, L. Eustace, 87, Jesmond Road, Newcastle-upon-Tyne... ... ... (E) { Graduate, Oct. 1889; Member, Oct. 1892 }
Smith, Thomas, Steam Crane Works, Old Foundry, Rodley, near Leeds (E) Oct. 1888
Smith, Thomas Edward, Messrs. John Smith & Sons, Newgate Street, Newcastle-upon-Tyne ... ... (E) April 1885
Smith, Wm., 152, Roker Avenue, Sunderland, M. ... ... (E) Nov. 1884
Smith, Wm. Stawart, West Villa, The Green, Wallsend-on-Tyne ... ... (S) { Graduate, Nov. 1893; Member, Dec. 1897 }
Sneddon, Alex. Russell, Lloyd's Register of Shipping, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ... (E SUR) Nov. 1899
Snook, Francis W. G., 10, Hawthorn Street, Newcastle-upon-Tyne (E) Dec. 1896
Soliani, Nabor, Col., Direttore del Cantiere Ansaldo, Sestri-Ponente, Italy ... ... (S) Jan. 1885

ELECTED.

Spark, H. King, Messrs. The Anti-Attrition Metal Co., Ltd., Emerson Street, Southwark, London, S.E. ... ... (E) May 1898
Spear, John, c/o Messrs. T. Wilson & Sons, Hull ... ... (E) Oct. 1887
Spearman, Richard, Eachwick House, Dalton, Newcastle-upon-Tyne (E) Feb. 1889
Spence, W. G., c/o Messrs. Wigham Richardson & Co., Neptune Works, Walker-on-Tyne (*Life Member*) ... ... (E) Nov. 1884
Spencer, Donald, 332, Stanhope Road, Tyne Dock, South Shields... (S) Oct. 1898
Spencer, J. W., Newburn Steel Works, Newburn-on-Tyne ... (E) Feb. 1885
Squire, Charles E., Waterside, Howath, Co. Dublin (E E) { Graduate, Nov. 1893; Member, Oct. 1898 }
Staig, William Andrew, Station Road, Wallsend-on-Tyne ... (E) Feb. 1897
Stanley, John T., 70, Falmouth Road, Heaton, Newcastle-upon-Tyne ... ... (E) Oct. 1898
Stansfield, George R., 1, Linden Gardens, Harton Village, South Shields... ... ... (E) Mar. 1891
Stephen, A. E., Linthouse, Govan, Glasgow ... ... (E & S) June 1896
Stephen, John Murray, Linthouse Engine Works, Govan, Glasgow (E) Oct. 1895
Stephens, H. C. J., 94, Fortess Road, Kentish Town, London, N.W. ... ... (E) { Graduate, Oct. 1890; Member, Nov. 1897 }
Stephenson, Bernard, 212, Anlaby Road, Hull ... ... (E) Dec. 1896
Stephenson, C., 2, Elm Terrace, The Green, Wallsend-on-Tyne ... (S) Nov. 1884
Stevenson, Wm., Bank Chambers, Sandhill, Newcastle-upon-Tyne (E) Nov. 1884
Stewart, James, 13, Otterburn Terrace, Jesmond, Newcastle-upon-Tyne... ... ... (E) Oct. 1890
Stirling, Andrew, Jun., 1, Greenvale Terrace, Dumbarton... ... (E) Feb. 1888
Stirzaker, J. C., 16, Grosvenor Place, Newcastle-upon-Tyne ... (E) Nov. 1884
Stoddart, A. Lane, York House, Heworth Village, Felling-on-Tyne, R.S.O. ... ... (S) Nov. 1898
Stoddart, J. E., Lloyd's Register of Shipping, White Lion Court, Cornhill, London, E.C. ... ... (E SUR) Oct. 1888
Stoddart, Swinton, 5, Ormonde Street, Sunderland ... (S) { Graduate, May 1885; Member, Nov. 1892 }
Summers, James, 114, Grange Road West, Middlesbrough ... (E) Mar. 1889
Surtees, Francis V., Westfield, Renfrew ... ... (S) Dec. 1892
Surtees, R., Frame House, Low Teams, Gateshead-on-Tyne ... (E) Nov. 1884
Swan, A. S., Guildhall Chambers, Newcastle-upon-Tyne ... ... (S) Nov. 1888
Swan, Charles Sheriton, c/o Messrs. C. S. Swan & Hunter, Wallsend-on-Tyne... ... ... (S) { Graduate, Nov. 1890; Member, Mar. 1894 }
Swan, H. F., North Jesmond, Newcastle-upon-Tyne (*Life Member*) (S) Nov. 1884
Swinburne, M. W., 117, Park Road, Newcastle-upon-Tyne ... (E) Nov. 1884
Swinburne, T. M., Bewick Road, Gateshead-on-Tyne ... ... (E) Jan. 1885
Swinney, W., 10, Wentworth Terrace, Westoe Lane, South Shields (E) Dec. 1888
Syme, James, Fairfield Works, Govan, Glasgow ... ... (E) Oct. 1892

T.

Tate, Chas. H., 7, Side, Newcastle-upon-Tyne ... ... (N A) Nov. 1884
Taylor, Alexander, Maritime Buildings, King Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Taylor, John, 1, St. Alban's Place, Tynemouth ... ... (E) Dec. 1894
Taylor, J. W. H. Maxwell ... ... (E) Feb. 1898

ELECTED.

Teasdale, John, c/o Messrs. Vickers, Son & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Mar. 1898
Thearle, Samuel James P., West View, St. Augustine's Avenue, South Croydon, Surrey ... ...(SUR) Feb. 1899
Thomas, Benjamin, 25, Seventh Avenue, Heaton, Newcastle-upon-Tyne ... ... (E) Feb. 1899
Thomas, William, Holme House Foundry, Wigan ... (F) { Graduate, Oct. 1895 / Member, Nov. 1899
Thompson, Arthur E., 19, The Crescent, Gateshead-on-Tyne ... (E) May 1898
Thompson, C. E., Ashville, Newcastle Road, Sunderland ... ... (S) Nov. 1884
Thompson, Jas., 2, Carlton Terrace, Sunderland ... ... (E) Dec. 1886
Thompson, John Augustus, 9, Billiter Square, London, E.C. (E & N A) Oct. 1892
Thompson, J. L., Westholme Hall, Winston-on-Tees ... ... (S) Nov. 1884
Thompson, Robert, North Sands Shipyard, Sunderland ... ... (S) Nov. 188
Thomson, James, M.A., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Ordnance Works, Elswick, Newcastle-upon-Tyne ... ... (E & N A) Nov. 1890
Thorn, W. H., 5, Waterville Terrace, North Shields ... ... (E) Nov. 1884
Thornton, James M., c/o Messrs. R. Gordon & Co., Post Office Buildings, Hudson Street, South Shields ... ... (E) April 1893
Thornton, Thomas Lee, 45, Northcote Street, Newcastle-upon-Tyne (E) Feb. 1898
Thyne, John Sinclair, 17, Boughton Street, Sunderland ... ... (S) Dec. 1899
Tinn, Fred. D., North View, Mowbray Road, South Shields ... (S) Nov. 1891
Tinn, George, 205, Cardigan Terrace, Gateshead-on-Tyne ... ... (E) Dec. 1897
Tocher, J. W., c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (S) Mar. 1898
Todd, John P., 13, Chatsworth Street, Sunderland ... ... (E) Dec. 1897
Todd, George William, 126 Bede Burn Road, Jarrow-on-Tyne (S) { Graduate, Jan. 1898 / Member, Dec. 1899
Toomer, C. R., Ravensworth, Westoe, South Shields ... ... (E) Jan. 1899
Toovey, Alfred F., Ovington Cottage, Prudhoe, Northumberland (E) Dec. 1894
Towers, Edward, Jun., 4, Latimer Street, Tynemouth (E) { Graduate, Nov. 1886 / Member, Oct. 1888
Toyne, G. A. Dryden, Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ...(SUR) April 1899
Trail, John, 21, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ...(M S) Oct. 1892
Traill, Robert, 8, Newcastle Street, North Shields ... ... (E) Oct. 1896
Trechmann, J. E., Norton Lodge, Stockton-on-Tees ... ... (E) Feb. 1898
Trewent, F. J., 43, Billiter Buildings, Billiter Street, London, E.C. ... ... (S) Dec. 1884
Trowell, Wm. John, Board of Trade Surveyor's Offices, Custom House, Arcade, Liverpool ... ... (E) Oct. 1894
Turnbull, John, 15, Woodbine Avenue, Wallsend-on-Tyne ... (E) Nov. 1898
Turner, S. J., 71, Warwick Street, Heaton, Newcastle-upon-Tyne (E) Mar. 1887
Turpie, David Whyte, c/o Messrs. W. Pickersgill & Sons, Southwick, Sunderland ... ... (S) Dec. 1895
Tuxen, Holger, Bureau Veritas Register of Shipping, Custom House Court, Quayside, Newcastle-upon-Tyne ... ... (S) Nov. 1896
Twaddell, James L., Green Bank, Jarrow-on-Tyne ... ... (S) Oct. 1891
Tweedy, G. F., Kelso House, Newcastle-upon-Tyne ... ... (E) May 1899
Tweedy, J., Neptune Works, Walker-on-Tyne ... ... (E) Nov. 1884

ELECTED.

Tweedy, John, 22, Lawson Street, North Shields ... ... (E) April 1899
Tyzack, George, Dean Street, South Shields... ... ... (E) April 1888

U.

Ulm, John, The Arsenal, Pola, Austria ... ... (E) Nov. 1885
Urquhart, Douglas M., 16, Forster Street, Sunderland ... ... (S) May 1899

V.

Vardey, George, 188, Helmsley Road, Newcastle-upon-Tyne (E) { Graduate, Oct. 1894 / Member, 1898 }
Vianson, N. E., *vid* Corsica 20/5, Genoa, Italy ... ... (E) Dec. 1885
Vick, R. W., Messrs. Furness, Withy & Co., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1888

W

Wadagaki, Yasuzo, Naval Dock, Yoka Suka, Japan ... ... (E) Jan. 1891
Wait, Thomas Herbert, Cail's Buildings, Quayside, Newcastle-upon-Tyne ... ...(C E) Dec. 1893
Wake, Tom, 2, Cliff Terrace, Hartlepool ... ... (E) April 1892
Wakeham, John F., 21, Tenth Avenue, Heaton, Newcastle-upon-Tyne ... ... (S) { Graduate, Mar. 1893 / Member, Oct. 1895 }
Walker, Archibald, 143, Leith Walk, Leith, N.B. ... ... (E) April 1887
Walker, Henry, 11, Oxford Terrace, Gateshead-on-Tyne ... ... (E E) Feb. 1893
Walker, James, c/o Messrs. River Tyne Commissioners' Office, Bewick Street, Newcastle-upon-Tyne ... ... (C E) Nov. 1898
Walker, John, c/o Messrs. R. Stephenson & Co., Limited, South Street, Newcastle-upon-Tyne ... ... (E & S) Nov. 1891
Walker, Sept. H., Denwick Street, Tynemouth ... ... (E) Nov. 1899
Wallau, J., 16, Woodhouse Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1884
Waller, Thomas Naunton, 10, Holly Avenue, Jesmond, Newcastle-upon-Tyne ... . (E) May 1898
Walliker, John George, c/o Messrs. Hodges & Walliker, Barry Docks, South Wales ... ... (E) May 1896
Wallis, Robert, Wh.Sc., Point Pleasant House, Wallsend-on-Tyne (E) April 1891
Walter, Max, Norddeutscher Lloyd, Central Bureau, Bremen ... (S) Feb. 1893
Walton, J. G., 26, Fenchurch Street, London, E.C. ... ... (E) Nov. 1884
Walton, Samuel, 5, Tyne View Terrace, South Shields ... ... (E) Dec. 1893
Warburton, F. J., 3, St. Nicholas' Buildings, Newcastle-upon-Tyne (C E) May 1900
Warburton, J., 4, Beauclerc Terrace, Sunderland ... ... (S) Nov. 1884
Warburton, John Arthur, 47, Harrogate Street, Sunderland (E) { Graduate, Mar. 1894 / Member, Nov. 1896 }
Ward, Herbert John, Mill Hey, Eastham, Birkenhead, Cheshire (SUR) Nov. 1898
Ward, John, c/o Messrs. W. Denny & Bros., Dumbarton ... ... (S) Dec. 1891
Wardale, Henry, 5, Collingwood Terrace, Gateshead-on-Tyne ... (E) Feb. 1888
Warden, Thomas M., 21, Windermere Street, Gateshead-on-Tyne (E) Oct. 1894
Wass, Archibald D., 148, Cardigan Terrace, Heaton, Newcastle-upon-Tyne ... ... (S) Nov. 1898
Watson, Thomas Henry, 10, Neville Street, Newcastle-upon-Tyne (SUR) Jan. 1896
Watts, Philip, Elswick Shipyard, Newcastle-upon-Tyne ... ... (S) Nov. 1885

ELECTED.

Wawn, Tom Noel, c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne ... ...(SUR) Jan. 1900
Weidemann, Nils, Det-Norske Veritas, Christiania, Norway ...(SUR) Jan. 1892
Weighton, R. L., M.A., Durham College of Science, Barras Bridge, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Weir, George Dobie, Sunderland Engine Works, South Docks, Sunderland ... ... (E) Oct. 1894
Weir, John, c/o Messrs. J. Scott & Co., Abden Works, Kinghorn, N.B. ... ... (E) Nov. 1884
Weir, William, 190, Nithsdale Road, Pollokshields, Glasgow ... (E) Nov. 1889
Welton, J. G., 41, Sydenham Terrace, Sunderland .. .. (E) Nov. 1893
West, Henry H., British and Foreign Chambers, 5, Castle Street, Liverpool ... ... (E & N A) Oct. 1886
Westgarth, Tom, Messrs. Sir C. Furness, Westgarth, & Co., Middlesbrough ... ... (E) Oct. 1886
Westmacott, Alfred, Foreland House, Bembridge, Isle of Wight ... ... (E) { Graduate, Dec. 1885; Member, Nov. 1892 }
Westmacott, P. G. B., Rose Mount, Sunninghill, Berks ... ... (E) Nov. 1884
Wheater, Chas. Busfield, 33, Rothwell Road, Gosforth ... ... (E) Oct. 1894
White, C., 13, Mosley Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
White, Ernest T., c/o Messrs. Willans & Robinson, Victoria Works, Rugby ... ... (E) { Graduate, May 1889; Member, Jan. 1894 }
White, R. Saxon, Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Whitfield, Ernest, 11, Victoria Terrace, Low Fell, Gateshead-on-Tyne... ... ... (E) Dec. 1899
Whitfield, Thomas, Messrs. Tyne Dock Engineering Co., South Shields ... ... (E) April 1896
Whittaker, Frederick W., Dockyard, Coburg Dock, Messrs. Mersey Docks and Harbour Board, Liverpool ... ... (E) Oct. 1892
Whyte, Wm., 12, Lombard Street, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Widdas, T. D., 56, Plasturton Avenue, Cardiff ... ... (SUR) April 1885
Wight, Henry D., 94, Cleveland Road, Sunderland ... ... (E E) Dec. 1898
Wildridge, Richard, 48, Sandyford Street, Glasgow ... (E) { Graduate, Oct. 1895; Member, Oct. 1898 }
Wilkie, J., 24, Camden Street, Southwick, Sunderland ... ... (E) Nov. 1884
Wilkin, Ernest V., 47, Saint Mary Axe, London, E.C. (C E) { Graduate, Nov. 1892; Member, Oct. 1898 }
Wilkinson, Thomas, 9, Laburnum Avenue, Wallsend-on-Tyne ... (S) Nov. 1899
Willcox, Henry Walker, 15, Norfolk Street, Sunderland ... ...(C E) Nov. 1897
Willcox, Percy F. C., 15, Norfolk Street, Sunderland ... ...(C E) Nov. 1897
Willcox, R. J. N., 15, Norfolk Street, Sunderland ... (E) { Graduate, Mar. 1892; Member, Dec. 1897 }
Williams, Thomas R. ... ... (S) Oct. 1895
Wilson, Henry J. H., 117, Bede Burn Road, Jarrow-on-Tyne ... ... (E) Nov. 1895
Wilson, James, Messrs. T. Richardson & Sons, Hartlepool Engine Works, Hartlepool ... ... (E) Jan. 1896
Wilson, John Paul, 9, The Knoll, Sunderland ... ... (S) Oct. 1895
Wilson, John Reginald, Lyndhurst, Gosforth, Newcastle-upon-Tyne ... ... (E E) { Graduate, Mar. 1894; Member, Dec. 1899 }
Wimble, Arthur, 1, Queen Street, Jersey ... ... (E) Dec. 1893

ELECTED.

Winstanley, P. D., Bureau Veritas Register of Shipping, 155, Fenchurch Street, London ... ... (S) Nov. 1884
Winter, Thor., Boulevards-gaten, 21, Helsingfors, Finland ... (E) Nov. 1893
Withy, H., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1884
Wood, Henry Alfred, Oakfield Road, North Ormesby, Middlesbrough-on-Tees ... ... (S) Dec. 1893
Wood, John Scott, 6, Eslington Terrace, Newcastle-upon-Tyne ... ... (S) { Graduate, Oct. 1891 / Member, Oct. 1896
Wood, Joseph, Foundry Manager, Deptford Yard Brass Works, Sunderland... ... ... (E) Mar. 1895
Wood, William, 6, Eslington Terrace, Newcastle-upon-Tyne ... (S) Nov. 1897
Wortley, Henry B., Kent House, Egerton Park, Rock Ferry, Birkenhead... ... ... (S) { Graduate, Jan. 1886 / Member, Nov. 1892
Wotherspoon, James Douglas, 221, Linthorpe Road, Middlesbrough (E) April 1900
Wray, Thomas W., Board of Trade Offices, Sunderland ... ...(SUR) Jan. 1895
Wright, R., 5, Hawthorn Terrace, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Wright, William Charles, 17, Wansbeck Gardens, West Hartlepool (E) Feb. 1898
Wyand, Frederick W., 13, Eldon Street, Newcastle-upon-Tyne ... ... (E E) { Graduate, Oct. 1894 / Member, Jan. 1898
Wyse, Thomas, North Lodge, Walker-on-Tyne ... ... (E) Nov. 1898

Y.

Young, Andrew, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (S) { Graduate, Feb. 1892 / Member, May 1893
Young, J. Denholm, 2A, Tower Chambers, Liverpool ... ... (E) Oct. 1888
Younger, R. Elmire House, Heaton, Newcastle-upon-Tyne ... (E) Nov. 1884

Z.

Zeeman, J. H., c/o Nederlandsch Indische Houtaankap, Maatschappij, Semerang, Java ... ... (S Oct.) 1889

ASSOCIATES.

A.

Andersen, Andrew P., Haldane House, Jesmond, Newcastle-upon-Tyne... ... ... (S O) Nov. 1899
Anderson, Daniel G., c/o Messrs. W. Angus & Co., Grainger Street West, Newcastle-upon-Tyne ... ... (A) Nov. 1893
Armstrong, S., Clifton Avenue, West Hartlepool ... ... (A) Nov. 1888
Arnott, James, 25, Dean Street, Newcastle-upon-Tyne ... ...(S O) Oct. 1895

B.

Bacon, William Charles, Chadwick House, West Hartlepool ...(S O) Dec. 1890
Barklam, George, Burnt Tree Villa, Tipton, Staffordshire ... (A) April 1888
Barr, John Smith, 16, Broad Chare, Quayside, Newcastle-upon-Tyne... ... ... (A) Nov. 1893
Barwick, J. S., Ashbrook Grange, Sunderland ... ...(S O) Nov. 1884
Bell, J. H.... ... ... (I & S M) Oct. 1887

ELECTED.

L.

Lloyd, John, Deptford Shipyard, Sunderland ... ... (A) Oct. 1894
Lockie, John, 21, Dean Street, Newcastle-upon-Tyne ... ... (S O) Oct. 1892
Lodwidge, Philip, Baltic Chambers, Sunderland ... ... (A) June 1896
Lord, W. R., 41, Queen's Road, Jesmond, Newcastle-upon-Tyne ...(M M) Feb. 1900

M.

Macarthy, George E., 9, Dean Street, Newcastle-upon-Tyne ...(S O) Oct. 1887
Mail, Douglas B., 3, St. George's Terrace, Jesmond, Newcastle-upon-Tyne ... ...(M S) Feb. 1895
Maughan, William, 13, Mosley Street, Newcastle-upon-Tyne ... (A) Feb. 1887
McIntosh, R. Y., 34, Dean Street, Newcastle-upon-Tyne ... ... (E A) Nov. 1891
McIntyre, John, 3, Abbotsford Terrace, Newcastle-upon-Tyne ... (S O) Jan. 1885
Meek, John George, 13, Belle Vue Park, Sunderland ... ... (A) Dec. 1894
Milburn, J. D., Queen Street, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Miller, T. R., 9, Great St. Helen's, London, E.C. ... ... (A & S O) Nov. 1884
Mitcalfe, John Stanley, Chairman of Northern Maritime Insurance Co., Maritime Buildings, Newcastle-upon-Tyne ... (A & S O) Jan. 1892
Moody, George Clark, H, King Street, Newcastle-upon-Tyne ... (S O) April 1900
Morton, Benjamin, 18, St. George's Square, Sunderland ... ...(SUP) Dec. 1895
Mulherion, G. F., Birtley Avenue, Tynemouth ... ... (A) Nov. 1884
Muller, J. C. F., 28, Vieille Route, Antwerp ... ...(SUR) Feb. 1890
Murray, Matthew, The Green, Wallsend-on-Tyne ... ... (A) Nov. 1893

N.

Nielsen, Hans Christian, 12, Cliff Terrace, Hartlepool ... ... (S O) Feb. 1898
Nixon, John, c/o Messrs. Blyth Shipbuilding Co., Blyth ... ... (A) Oct. 1894

O.

O'Hagan, James, 99, Quai de la Fosse, Nantes, France ... ... (A) Oct. 1888
Olsen, Hans Benedick, 70, Church Street, West Hartlepool ... (S O) Mar. 1893
Osbourne, Jas., 6, Ashbrook Terrace, Sunderland ... ... (S) Jan. 1885

P.

Park, Robert, Lauriston, Blackhill, Co. Durham ... ... (A) Dec. 1897
Parker, George, 62, John Street, Sunderland ... ... (A) Dec. 1899
Patterson, Thos., 2, The Elms, Sunderland ... ... (S) Jan. 1885
Petersen, William, Messrs. Petersen & Tate, Bank Chambers, Sandhill, Newcastle-upon-Tyne... ... ... (S O) Nov. 1893
Phalp, Oliver, Almora, 37, Richmond Road, Cardiff ... ...(SUR) Feb. 1889
Pinkney, Thomas, 3, Ashbrook Terrace, Sunderland ... ...(S O) Dec. 1886
Potts, Turnbull, Tyne Docks, South Shields... ... ... (SUR) Nov. 1898
Proctor, J. H., 22, Hawthorn Terrace, Newcastle-upon-Tyne ... (I M) Nov. 1893
Pybus, William M., Jun., 85, Osborne Road, Newcastle-upon-Tyne April 1899

R.

Radloff, Captain O., c/o Messrs. Russian Steam Navigation Co., Odessa ... ...(M S) Nov. 1891
Raine, John, Baltic Chambers, Sunderland ... ... (S O) Nov. 1897

ELECTED.

Ramsay, J. W., 13, Northbrook Road, Lee, Kent ... ... (A) Feb. 1885
Reichwald, A., Lombard Street, Newcastle-upon-Tyne ... ... (A) Nov. 1884
Reid, Sidney, Printer, Akenside Hill, Newcastle-upon-Tyne ... Nov. 1884
Renwick, G., Messrs. Fisher, Renwick & Co., Maritime Buildings, King Street, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Ritson, Arthur, 30, West Sunniside, Sunderland ... ... (S O) Feb. 1899
Robson, Frederick, 46, Dean Street, Newcastle-upon-Tyne (S I M) Oct. 1887
Robson, John William, G, King Street, Newcastle-upon-Tyne ... (M) April 1896
Robson, Thos., Causeway House, Sunderland ... ... (S O) Nov. 1884
Runciman, Walter, Fernwood House, Clayton Road, Newcastle-upon-Tyne ... ... (S O) May 1895

S.

Scholefield, A., 17, Sandhill, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Scott, W. H., Messrs. Scott Brothers, 46, Sandhill, Newcastle-upon-Tyne... ... ... (S O) Nov. 1884
Sisson, W. E., Northumberland Terrace, Tynemouth ... ... (A) Nov. 1899
Snowdon, W. F., 32, Side, Newcastle-upon-Tyne ... ... (E A) Dec. 1886
Squance, J. W., 13, The Avenue, Sunderland ... ... (M S) April 1888
Stephenson, George R., Northumberland Engine Works, Wallsend (A) Nov. 1899
Storey, Christopher, 28, Holly Avenue, Jesmond, Newcastle-upon-Tyne... ... ... (A) April 1896
Sutherland, Arthur M., 7, Collingwood Terrace, Newcastle-upon-Tyne ... ... (S O) Nov. 1897

T.

Tate, Arthur, Messrs. Petersen & Tate, Bentham Buildings. Side, Newcastle-upon-Tyne ... ... (O) Nov. 1893
Temple, George T., 20, Beach Avenue, Whitley Bay, Northumberland ... ... (A) Jan. 1899
Thompson, Wm. H., 5, Albany Gardens, Whitley Bay, Northumberland .. .. (A) Nov. 1899
Thompson, V. T., Baltic Chambers, Sunderland ... ...(S O) Dec. 1886
Todd, John Stanley, Percy Park, Tynemouth ... ... (U) Nov. 1895
Towers, Edward, 4, Latimer Street, Tynemouth ... ... (A) Oct. 1888
Towers, Michael G., Clementhorpe, South Shields ... ... (A A) Dec. 1899
Trechmann, Otto K., Church Street, West Hartlepool ... ... (S O) Oct. 1896
Tully, Robert, 9, The Lawe, South Shields ... ... (M S) May, 1900
Turner, Edwin, 32, Powell Road, Clapton, London, N.E. ... ... (A) Oct. 1895

W.

Wainford, Houston E., c/o Messrs. The Weardale Iron and Coal Co., Ltd., Tudhoe Ironworks, Spennymoor ... ... (A) Nov. 1899
Wallace, H. S., 17, Kingsley Place, Heaton, Newcastle-upon-Tyne (Life Associate) ... ... (S) May 1899
Watson, Thomas W., Gisburn House, Hartlepool ... ... (M S) Nov. 1890
Weatheral, Henry, 27, Alderson Street, West Hartlepool ... ... (A) Feb. 1893
Weller, William, 17, Lovaine Terrace, North Shields ... ... (S O) Dec. 1899
Wight, Robert M., 42, The Exchange, Cardiff ... ... (M) June 1896
Willis, Thomas W., Stockton Road, West Hartlepool ... ... (S O) Nov. 1899

ELECTED.

Wilson, F. Alfred, 45, West Sunniside, Sunderland ... ... (I M) Nov. 1893
Winstanley, Robt. Hope, 8, Kenilworth Road, Newcastle-upon-Tyne (A) Nov. 1897
Winter, Edward G. ... ... (A) May 1898

Y.

Yeoman, F., Messrs. Murrell & Yeoman, West Hartlepool ... (S O) Nov. 1888
Younger, Robert Laurie, Messrs. Greenock Steamship Co., Limited, Greenock ... ... (A) Feb. 1889

GRADUATES.

A.

Adams, Jas. Wilson, 8, Belle Vue Terrace, Gateshead-on-Tyne ... (E E) Nov. 1897
Adamson, Charles P., c/o W. Kinnaird, Esq., 175, Great Junction Street, Leith, N.B. ... ... (E) Nov. 1897
Agar, Alfred, c/o Messrs. Davison & Sons, Sirocco Works, Belfast, (E) Oct. 1898
Allen, John C., 14, North Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1899
Andrew, John Davis, 33, Osborne Road, Newcastle-upon-Tyne ... (E) Jan. 1898
Archer, J. Snowdon, 3, Burnside, Newcastle-upon-Tyne ... ... (E E) Nov. 1898

B.

Berriman, A. E., 12, Roxburgh Place, Heaton, Newcastle-upon-Tyne ... ... (E) Feb. 1900
Blake, Lionel J. B., 14, Woodhouse Terrace, Gateshead-on-Tyne... Nov. 1899
Bocler, Harry, 19, Azalea Terrace South, Sunderland ... ... (N A) Mar. 1898
Bolam, Joseph H., 46, Northumberland Street, Newcastle-upon-Tyne... ... ... (E) Nov. 1897
Borthwick, Robert J., 8, Kensington Terrace, Newcastle-upon-Tyne... ... ... (E) Dec. 1894
Brown, Thomas Scott, Jun., 18, Nixon Street, Newcastle-upon-Tyne ... ... (E) Oct. 1895
Browne, Benjamin C., Jun., 58, Brighton Grove, Newcastle-upon-Tyne... ... ... (E) Oct. 1898
Bullen, Thos. H., 14, Bede Burn Road, Jarrow ... ... Mar. 1900
Bulmer, Albert Edward, Inglewood, Prescot, Lancashire ... (E) Nov. 1895

C.

Calvert, E. A., 14, Albert Terrace, Tynemouth Road, North Shields (E) Oct. 1898
Carnegie, Alfred Q., 21, Eldon Place, Newcastle-upon-Tyne ... (E E) Nov. 1899
Carr, Ralph, Jun., Thornleigh, Clayton Road, Newcastle-upon-Tyne (E) Jan. 1894
Chapman, John Frederick, 82, Woodland Terrace, Old Charlton, London, S.E. ... ... (E E) Dec. 1895
Chicken, George Percy, 28, Lawton Street, Newcastle-upon-Tyne (E) Dec. 1898
Coulson, Richard H. A., 12, East View, South Shields ... ... (E) April 1897
Crawford, J. F., "Palmyra," St. George's Road, Waterloo, near Liverpool ... ... (E) Nov. 1893
Crookston, David D., 29, Laburnum Avenue, Wallsend-on-Tyne... (E) Nov. 1899
Cruickshank, Andrew, 52, Tennant Street, Hebburn-on-Tyne ... (E) Nov. 1899
Currie, Hugh B., 41, Eldon Street, Newcastle-upon-Tyne... ... (E) Nov. 1897

ELECTED.

D.

Dalziel, E. ... ... (E) Feb. 1898
Danielsen, John William, 24, Cardigan Terrace, Heaton, Newcastle-upon-Tyne ... ... (E) Mar. 1899
Davison, Joseph P., 107, Clumber Street, Newcastle-upon-Tyne ... (S) Oct. 1898
Dewar, John, The Green, Wallsend-on-Tyne ... ... (E) Nov. 1899
Dilworth-Harrison, D. R., 8, Belle Vue Terrace, Gateshead-on-Tyne ... ... (E E) Nov. 1899
Dixon, John Thomas, 27, Meldon Terrace, Heaton, Newcastle-upon-Tyne ... ... (E) Dec. 1899
Dobson, William Gordon, The Chesters, Jesmond, Newcastle-upon-Tyne... ... ... (S) Feb. 1896
Donaldson, Henry B., 10, Lily Crescent, Jesmond West, Newcastle-upon-Tyne ... ... (S) Nov. 1897
Doxford, Robert, Jun., Silksworth Hall, Sunderland ... ... (N A) Feb. 1897

E.

Edminston, Alex. R., c/o Mrs. Sheffield, 10, Beaconsfield Square, Hartlepool ... ... (E) Jan. 1898

F.

Featherstonhaugh, Albany, 13, Park Place West, Sunderland ... (E) Oct. 1894
Fenton, Frederick, 15, Kent Street, Jarrow-on-Tyne ... ... (S) Mar. 1898
Fletcher, Arthur C., 5, The Avenue, Wallsend-on-Tyne ... ... (E) Mar. 1900
Forster, Charles M., Oakfield, Ryton-on-Tyne ... ... (E) Oct. 1898

G.

Glahome, John W., 43, North Terrace, Wallsend-on-Tyne... ... (E) Nov. 1899
Gravell, Arthur, 14, Hedley Street, Gosforth, Newcastle-upon-Tyne... ... ... (E E) Jan. 1899

H.

Haig, William G., 31, Harrogate Street, Sunderland ... ... (S) May 1899
Hamilton, James, Beech House, Mile End, Stockport ... ... (E) Nov. 1897
Hammond, F. Chas., Park Head, Jesmond Dene, Newcastle-upon-Tyne ... ... Nov. 1899
Hay, John, 44, Fern Avenue, Newcastle-upon-Tyne ... ... (E) Dec. 1898
Heck, John S., 10, Bristol Terrace, Newcastle-upon-Tyne ... ... (E) Dec. 1899
Hedley, Ralph, 19, Belle Grove Terrace, Newcastle-upon-Tyne ... (E E) Dec. 1899
Hepburn, James M., 17, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ... (E) Nov. 1895
Hills, Lawrence, 2, Somerset Terrace, East Boldon, Newcastle-upon-Tyne ... ... (S) Nov. 1898
Hutchinson, Wm. S., Rock Lodge, Roker, Sunderland ... ... (S) May 1899
Hutton, John S., Kildale, Clayton Road, Newcastle-upon-Tyne (E) Nov. 1897

J.

James, Matthew C., Jun., 6, Park Terrace, Gateshead-on-Tyne ... (E E) May 1899
James, Wm. E., 6, Park Terrace, Gateshead-on-Tyne ... ... (S) May 1899

ELECTED.

Jobling, Vivian, Whickham, Swalwell, R.S.O. ... ... (E) Oct. 1898
Joicey, Edward James, 30, Bewick Road, Gateshead ... ... (E) April 1900
Jupp, William H., 121, Bede Burn Road, Jarrow-on-Tyne... ... (E) Nov. 1899

K.

Kent, Samuel N., Lindenhurst, Heaton, Newcastle-upon-Tyne ... (E) Mar. 1896
Kincaid, Thomas L., 29, Laburnum Avenue, Wallsend-on-Tyne... (E) Nov. 1899
Kinsey, Wm. E., 9, Laburnum Avenue, Wallsend-on-Tyne ... (E) May 1899

L.

Laing, Bryan, Thornhill, Sunderland... ... ... (S) Dec. 1895
Lee, Hugh Warren, 88, Manor House Road, Jesmond, Newcastle-upon-Tyne ... ... (E) Dec. 1899
Lindsay, James D., Fernville, Gosforth, Newcastle-upon-Tyne ... (E E) Jan. 1897
London, W. J. A., 104, Sandyford Road, Jesmond, Newcastle-upon-Tyne ... ... (E) May 1898
Luhrs, H., 10, Lodge Terrace, Wallsend-on-Tyne ... ... (E) Nov. 1899

M.

Mace, George, c/o Messrs. Burmeister, Weins & Co., Copenhagen, Denmark ... ... (S) Oct. 1896
Mathews, Gordon D., 9, St. Luke's Terrace, Pallion, Sunderland... (E) Dec. 1899
McCoull, Cecil, Ovington House, Ovingham, R.S.O., Northumberland .. .. (E) Oct. 1895
McRobie, Frank, 20, Victoria Street, Newcastle-upon-Tyne ... (E) Mar. 1889
Melville, James, Duke Street, Barrow-in-Furness ... ... (E) Feb. 1900.
Milne, George Murray, 17, East Percy Street, North Shields ... (S) Feb. 1898
Mitchell, William, Glen Street, Hebburn-on-Tyne ... ... (S) Jan. 1898
Moore, Jas. Forster ... ... (E E) Nov. 1897
Moss, William, 6, Station Road, Wallsend-on-Tyne ... ... (E) Jan. 1898
Murray, Athole J., Hassendean, Beech Grove, Newcastle-upon-Tyne ... ... (S) Nov. 1897

N.

Nelson, George, 63 Stratford Road, Heaton, Newcastle-upon-Tyne (E) Jan. 1900
Nesfield, Albert C., 11, Victoria Terrace, Whitley Bay ... ... (E) Nov. 1898
Nesfield, Arthur, 11 Victoria Terrace, Whitley Bay ... ... (E) Nov. 1898
Nixon, John Robert, 4, Bath Terrace, Blyth ... ... (E) Feb. 1898

O.

Olsen, Hans B., Jun., Wellington Road, West Hartlepool... ... (E) Feb. 1895
Owen, Charles E. A., 13, Gloucester Terrace, Newcastle-upon-Tyne (S) Nov. 1898

P.

Patterson, Robt. O., Thorneyholme, Blaydon-on-Tyne ... ... (E) Jan. 1895
Piercy, Guy ... ... (S) Dec. 1898

ELECTED.

Posgate, James Stephen, 11, Wandsworth Road, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1895
Potts, Arthur W., 9, Beaconsfield Terrace, Gateshead-on-Tyne ... (E) Oct. 1898
Potts, Joseph, 14, Moreland Street, West Hartlepool ... ... (E) Feb. 1898
Potts, Herbert Joseph, 42, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ... (E) Dec. 1899

R.

Rappoport, Fred. G., 14, Sunbury Avenue, West Jesmond, Newcastle-upon-Tyne ... ... (E) Mar. 1894
Robinson, Francis, Willington Rectory, Newcastle-upon-Tyne ... (E) Nov. 1897
Robinson, Frank Bertie, 10, Dickinson Crescent, Gosforth, Newcastle-upon-Tyne ... ... (E) Mar. 1899
Robson, Robert, 166, Rye Hill, Newcastle-upon-Tyne ... ... (E E) Dec. 1894
Robson, Geo., Jun., 9, Wellington Terrace, South Shields ... ... (E) Mar. 1899
Routledge, Herbert J., Stapleton House, Jarrow-on-Tyne ... (E E) Mar. 1897
Ruhaak, G. H. Mülder, 28, Gelderschekade, Rotterdam ... ... (E) Feb. 1898

S.

Sanderson, Thomas H., 31, Park Road, Jarrow-on-Tyne ... ... (E) Feb. 1898
Scott, George, 36, Bede Burn Road, Jarrow-on-Tyne ... ... (E) Jan. 1900
Shand, William Lamont, 64, Osborne Road. Newcastle-upon-Tyne (E) Nov. 1895
Smith, Frederick H., Construction Department, Messrs. Elder, Dempster & Co., African House, Water Street, Liverpool (E & S) May 1898
Smith, John E., 15, Eslington Terrace, Newcastle-upon-Tyne ... (E) Nov. 1897
Sprague, Cycil R., B.Sc., 16, Wentworth Place, Newcastle-upon-Tyne... ... ... (E) Nov. 1899
Stagg, Albert E., The Rectory, Willington-on-Tyne ... ... (E) Nov. 1899
Steele, Wm. S., 4, Scott Street, Byker, Newcastle-upon-Tyne ... (E) Nov. 1898
Stranbenzee, H. T. V., 15, Jesmond Vale Terrace, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Stuart, John, 57, Heaton Park Road, Newcastle-upon-Tyne ... (E) Dec. 1895
Swinburn, M., Fraser Terrace, Heworth, Felling-on-Tyne, R.S.O. (S) May 1899

T.

Tate, Frank W., 16, Lincoln Street, Gateshead-on-Tyne ... (E) Nov. 1898
Temperley, Nicholas R., 4, Carlton Terrace, Low Fell, Gateshead on-Tyne ... ... (E E) Dec. 1898
Thew, Charlton, 15, St. George's Terrace, Newcastle-upon-Tyne ... (E) Dec. 1899
Thomas, John P. ... ... (E) Dec. 1897
Thompson, John, Wincombles House, Walker-on-Tyne ... ... (S) Nov. 1899
Todd, George William, 126, Bede Burn Road, Jarrow-on-Tyne ... (S) Jan. 1898
Turner, Charles N., 21, Landsdowne Terrace, Gosforth, Newcastle-on-Tyne ... ... (E) April 1896

V.

Varty, B. S., 16, Hawthorn Street, Newcastle-upon-Tyne ... ... (S) Oct. 1895
Vaughan, Wm. A., The Poplars, Gosforth, Newcastle-upon-Tyne... Jan. 1898

ELECTED.

W.

Waddingham, W. H., 42 Lovaine Place, Newcastle-upon-Tyne ... (E) Nov. 1897
Wailes, William C., Jesmond House, Richmond Road, Cardiff ... (E) Nov. 1898
Walker, Gavin Knox, Beverley, The Ridgeway, Enfield, London, N. (E) Mar. 1894
Watson, John, 104, Cardigan Terrace, Heaton, Newcastle-upon-Tyne ... ... (S) Dec. 1897
Watson, Kenneth, 3, Rosella Place, North Shields ... ... (E) Mar. 1899
White, Percy M., c/o Messrs. Hawthorn, Leslie, & Co., St. Peter's Works, Newcastle-upon-Tyne ... ... (E) Nov. 1899
Whittle, J. A., 52, Kenilworth Road, Newcastle-upon-Tyne ... (E) Nov. 1898
Williams. Edward, Bradley Terrace, Walker-on-Tyne ... ... (E) Mar. 1899
Wilson, Percy P., 5, Elwin Terrace, Sunderland ... ... (S) Jan. 1896
Wilson, William S., 123, Osborne Road, Newcastle-upon-Tyne ... (E) Nov. 1897
Winstanley, P. G., 6, Joannah Street, Newcastle Road, Sunderland ... ... (S) Oct. 1898
Wood. Lionel, 65, Princes Gate, London, S.W. ... ... (E E) Nov. 1897
Wotherspoon, William L., 9 Jackson Street, Chester Road, Sunderland... ... ... (E) Jan. 1898
Wraith, Herbert O., 7 Kensington Terrace, Gateshead ... ... (E E) Feb. 1900
Wright, George Hudson, 23 Albury Park Road, Tynemouth ... (E E) Feb. 1896

THE NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

Constitution and Bye-Laws,

ADOPTED AT A GENERAL MEETING ON THE 4TH MARCH, 1885.

REVISED AT THE CLOSING BUSINESS MEETING HELD ON MAY 4TH, 1887.

RE-REVISED AT THE CLOSING BUSINESS MEETINGS HELD ON MAY 9TH, 1888, MAY 13TH, 1889, MAY 11TH, 1891, MAY 14TH, 1895, AND MAY 13TH, 1898.

CONSTITUTION.

I.—The NAME of the Association is "The North-East Coast Institution of Engineers and Shipbuilders." Name.

II.—The OBJECTS for which the Institution is established are :—The advancement of the science and practice of Engineering and Shipbuilding, and the interchange of ideas and information amongst its members, by means of meetings for the reading and discussion of papers relating thereto, and placing on record its transactions. Objects.

III.—The Institution shall consist of Honorary Members, Members, Associates, and Graduates.

IV.—HONORARY MEMBERS shall be such distinguished persons as the Council may elect. Honorary Members.

V.—MEMBERS shall be Principals or Principal Managers engaged in Engineering or Shipbuilding; Civil, Military, or Mining Engineers, or Naval Architects; whose subscription shall be Two Guineas per annum: and other persons engaged in the above professions; whose subscription shall be One Guinea per annum. Members.

VI.—ASSOCIATES shall be such persons as are not strictly Engineers or Shipbuilders, but are connected with or interested in such pursuits, and are deemed by the Council to be eligible for Associate membership. Their subscription shall be C Guinea per annum. Associates.

Graduates.

VII.—GRADUATES may be persons under twenty-four years of age, engaged in study or employment to qualify themselves for any of the above professions. Their subscription shall be Half-a-Guinea per annum.

Life Members and Associates.

VIII.—Any MEMBER may become a LIFE MEMBER by a single payment of Twenty Guineas, or any ASSOCIATE may become a LIFE ASSOCIATE by a single payment of Ten Guineas. All such compositions shall be deemed to be capital moneys of the Institution.

Officers.

IX.—The COUNCIL of the Institution shall be elected from and by the Members, and shall consist of one President, the Past-Presidents, eighteen Vice-Presidents, fifteen Ordinary Members of Council, and an Honorary Treasurer.

Election of Officers. See Bye-Law No. 11.)

X.—The President and Honorary Treasurer shall be elected annually. Three Vice-Presidents and five Ordinary Members of Council shall be elected annually. The retiring Vice-Presidents shall be those who have been in office for the longest period, and Ordinary Members of Council those who have served three years from their last election.

The President shall be eligible for re-election for a second year; should he be re-elected he shall retire at the conclusion of his second year of office, and shall not again be eligible until after an interval of one year.

The retiring Vice-Presidents shall be eligible for re-election. The retiring Ordinary Members of Council shall not be eligible for re-election to the same office until after an interval of one year, but shall be eligible for election to any other office.

The Honorary Treasurer shall be eligible for re-election annually, or for election to any other office.

Honorary Members' Privileges.

XI.—Honorary Members may attend all the General Meetings, they may read papers, take part in discussions, in voting, in moving and supporting resolutions, in presentation of notices of motion, or in requisitions for Special Meetings, and in the proposition of new members; they shall also receive copies of the Transactions.

Members' Privileges.

XII.—Members shall have all the privileges of the Institution as enumerated in the foregoing paragraph, and shall be eligible for office.

Associates' Privileges.

XIII.—Associates shall have all the privileges enumerated in paragraph XI. They shall be eligible for office as Ordinary Members of Council.

XIV.—Graduates may attend all the General Meetings, they may read papers, take part in discussions, and support resolutions; they shall also receive copies of the Transactions, but shall not sign proposals for new members, vote, nor be eligible for office. Graduates' Privileges.

XV.—The General Meetings of the Institution shall be held during the months of October to May, inclusive, of each year. General Meetings.

NOTE.—When the word Member is initialled with a capital letter it signifies a member under paragraphs IV. and V., but when initialled with a small letter, it signifies a member of any class of the Institution membership.

BYE-LAWS.

MEMBERSHIP.

1.—Every candidate for admission as a Member, Associate, or Graduate shall be proposed and recommended according to the Form A in the Appendix, in which form the name, usual residence or the place of business, the qualification for, and proposed class of membership of the candidate shall be distinctly specified. Proposals for Graduates must give the date of, and age, last birthday. Candidates for Admission.

The form shall be signed by a Member or Associate of the Institution, as proposer, and by at least other three Members or Associates as supporters, certifying a personal knowledge of the candidate.

The proposal so made shall be submitted to the Council, when, if it be approved, the Chairman shall sign the approbation, which shall be inserted in the notice calling the next General Meeting, when the candidate shall be balloted for, and shall be accepted if three-fourths of the votes are favourable.

2.—Graduates desirous of becoming Members shall be proposed and recommended according to the Form B in the Appendix. Graduates becoming Members.

The proposal so made shall be submitted to the Council, who shall agree to or reject it.

3.—The balloting for membership shall be conducted in the following manner:—Each member shall be supplied by post with a list of the names of the candidates, according to the Form C in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected. These lists may be Balloting for Members.

returned to the Secretary by post, or may be deposited in the ballot-box by the voter in person on entering a meeting at which an election is to take place. The ballot-box will be closed at ten minutes after the advertised time of meeting. The lists shall then be handed over to the Chairman, who shall appoint two Scrutineers to examine them, after which examination the Chairman shall inform the meeting of the result.

Candidates to receive Notice of Election.

4.—Notice of Election as a member shall be sent to the candidate within one week after his election, according to the Form D in the Appendix; but his name shall not be added to the list of Members, Associates, or Graduates of the Institution, until he shall have paid his first annual subscription.

Rejection of Candidates.

5.—In case of rejection of the candidate, no mention thereof shall be made in the minutes, nor shall any notice be given to the unsuccessful candidate.

Subscriptions payable in Advance.

6.—All subscriptions shall be payable in advance, and shall become due on the 1st of August each year. Any Member, Associate, or Graduate, wishing to retire from the Institution shall continue to be liable for his annual subscription until he shall have given formal notice of his retirement to the Secretary, which notice must be given on or before the 31st of August in each year. Application for membership may be made at any time during a Session, and the subscription shall cover the membership up to the 1st of August following.

Receipt of Subscription.

7.—On payment of each subscription the Secretary shall forward to the member an official receipt.

Questions of Privilege.

8.—On question of privilege.—Any person who may be unknown in the meeting shall only be able to claim the privilege in question on proving his membership for the current Session.

Arrears of Subscriptions.

9.—Any member whose subscription is one year in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form E in the Appendix; and in the event of its continuing in arrear until the end of that Session after such application, the Council shall have the power, after remonstrance by letter, according to the Form F in the Appendix, of declaring that the defaulter has ceased to be a member.

Power of Council to remove Name from List of Members.

10.—The Council may refuse to continue to receive the subscriptions of any member who shall have wittingly acted in contravention of the Regulations of the Institution, or who shall,

in the opinion of the Council, have been guilty of such conduct as shall have rendered him unfit to continue his membership; and the Council may remove his name from the list of members: and such person shall thereupon cease to be a member of the Institution. Notice of such action of the Council shall be forwarded to the person in question, in accordance with the Form G in the Appendix. The reason for such action of the Council shall not be stated to the person expelled, without the sanction of the Council.

OFFICERS.

Election of Officers.

11.—The Annual Election of Officers shall be conducted in the following manner:—The Council shall meet in March or April, and shall arrange a list of nominations, in accordance with the Form H in the Appendix. It shall nominate new names in the place of the retiring Members, and the number of nominations shall be one in excess of the number required in each section of the Council. Such list shall be presented at the General Meeting immediately preceding the last General Meeting of the Session, and any Member present shall be at liberty to nominate additional Members. The list shall show who remain in office throughout the Council, and who are retiring. A copy of this ballot list shall be forwarded to each Member and Associate, together with a complete list of Members of Council, to be filled in, in accordance with the instructions printed in the ballot form, and to be returned to the Secretary to be opened in the presence of the Council, at a Council Meeting which shall be held in April or May, when the scrutiny and counting shall be carried out by the Council. Any Member in voting shall be at liberty to erase any name or names from the list and substitute the names of any other person or persons eligible for each respective office other than those already placed on the ballot list by the Council and Members of the Institution.

Any voting paper returning either more or less than one President, eighteen Vice-Presidents, one Honorary Treasurer, and fifteen Ordinary Members of Council, shall be disqualified for the section or sections in which such errors occur, and the votes shall be lost for the said section or sections. The votes given as President, to a Member who is not elected President, shall count to him as a Vice-President; the votes given as Vice-President, or Treasurer, to persons not so elected, shall count to

them as Ordinary Members of Council, unless they have just completed a term of office in such capacity.

The voting list shall not be sent to any Member and Associate whose subscriptions are more than one year in arrear; nor shall any such Member be nominated on the list. For this purpose, the Secretary shall prepare, previously to the meeting of Council, a list of those Members whose subscriptions are more than one year in arrears.

Ballot to be declared at May Meeting.

12.—The result of the ballot for Officers shall be declared at the Closing Business Meeting, to be held in May, at which meeting general business shall be transacted. At this meeting the newly-elected Officers, after being declared, shall enter into office; and this shall be the last meeting of the Session.

Power of Council to fill up Casual Vacancy.

13.—The Council shall have power to supply any casual vacancy within itself (including any casual vacancy in the office of President), which shall occur between one May Meeting and another; and the Officers so appointed shall retire when the persons whose places they fill would have retired. Vacancies not filled during the year shall be filled at the General Election.

GENERAL MEETINGS.

General Meetings.

14.—The Annual General Meeting shall take place in October, and the Closing Business Meeting in May; each of these meetings shall be held in Newcastle-upon-Tyne. The Ordinary Meetings shall take place in the second week in each following month during the Session, unless otherwise arranged by the Council, and at such hours and places as the Council may determine.

Notice of Meetings

15.—Seven clear days' notice of every General Meeting, Ordinary or Special, specifying the nature of business to be transacted, shall be given to every member of the Institution.

Special General Meetings.

16.—A Special General Meeting may be convened at any time by the Council, and such meeting shall be convened by the Council whenever such is the declared wish of a General Meeting, or whenever a written requisition, signed by twenty members, specifying the object of the meeting, is left with the Secretary. If, for fourteen days after the delivery of such requisition, a meeting be not convened in accordance therewith, the requisitionists, or any twenty members of the Institution, may convene a Special Meeting in accordance with the requisition. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting.

17.—Twenty Members shall constitute a quorum for the purpose of a meeting other than a Special Meeting. Thirty Members shall constitute a quorum for the purpose of a Special Meeting. Quorum

18.—The President shall be chairman at every meeting, and in his absence, one of the Past-Presidents or one of the Vice-Presidents; or in the absence of these, an Ordinary Member of Council shall take the chair; or if no Member of Council be present and willing to take the chair, the meeting shall elect a Chairman. Chairman at Meetings.

19.—The decision of a General Meeting shall be ascertained by a show of hands; or, when five Members or Associates shall demand, or the Chairman may think it desirable, the decision shall be taken by ballot. The manner of counting the votes shall be at the discretion of the Chairman, and an entry in the minutes, signed by the Chairman, shall be deemed sufficient evidence of the decision of a General Meeting. In cases of equality of votes, the Chairman shall have a casting vote; otherwise he shall not vote. Decisions of General Meetings.

20.—Questions of a personal nature arising in a General Meeting, shall, if possible, be referred to the Council, otherwise the decision of the meeting shall be taken by ballot on a motion or amendment put to the meeting. The ballot shall be taken by the voters (being Members or Associates) writing "for" and "against" on a slip of paper. The slips shall be folded and collected, and then counted in the presence of the meeting, and the result announced by the Chairman. Should fewer than twenty votes be given, it shall be understood that the question is shelved, and the votes shall be destroyed without being opened. Questions of a Personal Natu in General Meetings.

21.—At every General Meeting of the Institution, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; business arising out of these minutes shall then be transacted. The Secretary shall read any notices which may have to be brought before the meeting. Notices of motion may then be given, and other business of the Institution may be attended to; but when a paper is to be read, the foregoing business shall not be extended beyond half-an-hour after the advertised time for commencing the meeting. The paper or papers for the evening shall then be read and discussed. Transactions of Business Gener Meetings.

22.—If within half-an-hour after the time fixed for holding a General Meeting a quorum is not present, the meeting shall be Dissolving a General Meetin

dissolved, and all matters which might, if a quorum had been present, have been done at the meeting so dissolved, may forthwith be done on behalf of the meeting, by the Council; except the reading or discussion of a paper, which shall not proceed in the absence of a quorum.

Adjourning a General Meeting.

23.—Any General Meeting of the Institution may be adjourned by a vote of the Members and Associates present if there be a quorum; if there be not a quorum, the case shall be met by the preceding paragraph.

Introduction of Friends.

24.—Each member shall have the privilege of introducing one friend to the General Meetings, whose name must be written in the Visitors' Book, together with that of the member introducing him; but if the introducing member be unable to attend the meeting, he may send the name of the visitor to the Secretary. During such portions of any of these meetings as may be devoted to any business connected with the management of the Institution, visitors may be requested by the Chairman to withdraw. This shall be done if five Members or Associates, or both, present request it.

COUNCIL MEETINGS.

Council Meetings.

25.—The Council shall meet before each General Meeting, or on other occasions when the President shall deem it necessary; being summoned in either case by circular, stating the time of meeting, and the business, so far as is known.

Convening Meeting for Expenditure of Funds.

No business involving expenditure of the funds of the Institution (except by way of payment of current accounts) shall be transacted at any Council Meeting, unless the circular gives six clear days' notice, and states the business.

Discussions of Personal Character.

All discussions of a personal character in the Council shall be considered and treated as being strictly confidential.

Regulation of Proceedings.

26.—The Council may regulate its own procedure, and delegate any of its powers and discretions to any one or more of its number.

Chairman and Quorum.

The President shall, *ex-officio*, be chairman of all Council Meetings, and in his absence one of the Past-Presidents or one of the Vice-Presidents shall take the chair; or in the absence of these, one of the Ordinary Members of Council shall be elected to take the chair. Five members of Council, including the Chairman, shall form a quorum.

Sub-Committees.

In the appointment of Sub-Committees, the Council shall determine the number which shall form a quorum in each case,

and shall appoint a Chairman. These regulations shall not affect the Finance Committee.

Sub-Committees

27.—The Council may appoint Committees either from itself, or with the assistance of persons outside, for the purpose of transacting any special business, or of investigating specific objects connected with the work and interests of the Institution.

Sub-Committees.

28.—All Committees or Sub-Committees shall be appointed by the Council, and shall be subject to that body, and shall report to it. The Council shall act upon these reports or recommendations as it may think best. The President shall, *ex-officio*, be a member of all Committees.

Communication to Council.

29.—Any member may by communication addressed to the Secretary petition the Council to lay before a General Meeting of the Institution the contents of any letter which shall in a short, concise, and clear manner draw the attention of the Institution to public matters of importance in connection with legislation proposed by any governing body in reference to the construction of ships, machinery, or the working of the same, so that members may by their scientific and practical knowledge demonstrate the soundness or otherwise of the proposed measure.

Invitation to Strangers.

30.—The Council may invite to General Meetings or to Council Meetings any person or persons whose presence and assistance it may desire, and strangers so invited shall be permitted to take part in the proceedings, but not to vote.

Secretary and Treasurer's Duties.

31.—The Secretary, who shall also act as Treasurer, shall be appointed by and act under the direction and control of the Council, and shall be paid such salary as the Council shall determine. He shall attend all meetings, Council and General, and shall take minutes of the proceedings, and enter them in proper books provided for the purpose. He shall write the correspondence of the Institution and Council, read minutes and notices at meetings, report discussions, and, if required by the Council, prepare papers for reading and publication, and read papers and communications at the meetings. He shall receive all payments due to the Institution, and shall bank the cash in hand whenever it amounts to ten pounds. The bank shall be determined by the Council and the banking account shall be in the names indicated in connection with the Finance Committee. He shall keep a cash account book, general and detail, which shall on all occasions be open to inspection by the Finance

Committee or by the Council. He shall keep a register of the names of members, so arranged as to distinguish all members whose subscriptions are in arrear. He shall also perform whatever other duties are indicated in the Bye-Laws of the Institution as appertaining to his department; and shall remain in office during the pleasure of the Council. He shall not vote on any resolution.

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32.—The following Sub-Committees shall be appointed annually at the first meeting of the Council in each Session:—(1) A Finance Committee, to consist of seven persons, viz.: one Past-President or Vice-President, who shall be Chairman; five Members of Council, and the Honorary Treasurer of the Institution; three of whom shall form a quorum. The Treasurer shall be empowered to pay all amounts due from the Institution which are under two pounds. All amounts of two pounds and upwards shall be paid by cheque, signed by the Chairman of the Finance Committee (or in his absence, by the President or a Past-President), the Secretary and the Honorary Treasurer. (2) A Reading Committee, to consist of six members of Council. No member who has served on this Committee for three years in succession shall be eligible for re-election until after an interval of one year. (3) A Library Committee, in accordance with Library Rules, Nos. 1 and 3. (4) A Graduates' Award Committee to consist of five members.

TRANSACTIONS.

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33.—All papers shall be forwarded to the Secretary at least five clear weeks before the proposed date of reading. The Secretary shall submit them for approval to the Council, and on their general approval they shall be handed to the Reading Sub-Committee, three of whom at least, shall read the paper through. The Reading Sub-Committee shall be at liberty to strike out any parts which, in their opinion, ought not to be read. They may also make any suggestions to the author as to points which might with advantage be inserted or altered. A synopsis of the subject-matter of each paper shall be forwarded to the Secretary, by the writer, for insertion in the circular convening the meeting at which the paper is to be read.

rinting ransactions.

34.—The papers read, and the discussions on them, or such portions of them as the Council shall select, shall be printed for

distribution among the members, each of whom shall receive a copy. These Transactions shall be edited by the Secretary, in accordance with instructions of the Council, who shall have power to omit parts of discussion which may be foreign to the subject, or which it may be deemed undesirable to retain. Each paper shall bear the date on which it was read in General Meeting.

Copy of Paper supplied to members befor reading, etc.

35.—Copies of papers to be read during any Session will be sent seven days before the date of reading to members who shall have applied to the Secretary for them, in writing, at the commencement of the Session. The discussion on a paper shall not be considered closed on the evening on which it is read, but shall be open for renewal at a subsequent meeting, prior to the reading of the paper set down for that date.

Proofs sent to members for Correction.

36.—The Secretary shall send to each speaker as soon as possible after a General Meeting a copy in manuscript of the speaker's own remarks for correction. This copy must be returned to the Secretary within four days. A printed proof will also be sent to each speaker for further revision; this must be returned to the Secretary within three days, otherwise it will be deemed correct, and printed off after receiving verbal corrections.

Liberty to Pri Explanatory Notes.

37.—The Council shall be at liberty to print as Transactions, either with the papers and discussions or separately, explanatory notes, etc., communicated after the reading or discussing of a paper. Such communications must be approved by the Reading Committee, and shall bear the date on which they shall have been received by the Secretary.

Institution no responsible fo statements.

38.—The Institution shall not be held responsible for the statements and opinions advanced in any of the papers which may be read, or in the discussions which may take place at the Meetings of the Institution.

Copies of Tra actions to be s to members.

39.—Twenty copies of each paper and discussion shall be presented to the author of the paper, for private use, and one copy shall be sent to each member. When a paper is prepared by two authors, fifteen copies shall be presented to each. Duplicate copies of parts of the Transactions mislaid or lost by members cannot be supplied to them, except as provided for in Bye-Law 42.

Transactions supplied to m bers in Arrear

40.—The Transactions shall not be supplied free to members whose subscriptions are unpaid.

[embers not to ...ive Trans- ...ons till after ...t Payment.

41.—Any member elected at any time between the Annual General Meetings shall be entitled to copies of all the Transactions issued during the Session to which his first subscription applies; but not until the subscription has been paid.

ransactions the roperty of the istitution.

42.—The Transactions of the Institution shall be the exclusive property of the Institution, and shall be published only by the authority of the Council. Additional copies of papers required by authors for their private use can only be procured from the Secretary, at prices fixed by the Council from time to time, and these copies must contain the whole of the discussion following the papers, and be bound in the usual cover, with the addition of the following words:—"By permission of the Council," and "Excerpt Minutes of Proceedings." Duplicate volumes and copies of parts of the Transactions, if in print, can also be obtained from the Secretary, and shall be sold only by him, in such manner and at such prices as the Council shall have fixed.

ule of iscussion.

43.—During a discussion upon any paper, no person shall be at liberty to speak more than once (except by way of explanation), nor for a longer period than ten minutes.

ACCOUNTS, &c.

ccounts.

44.—The Council shall present the yearly accounts (up to the 31st of July preceding) at the Annual General Meeting in October of each year, after they have been audited by a professional Accountant, appointed by the members at the Closing Business Meeting in May.

ustees.

45.—The capital, stock, and funds of the Institution shall be vested in the names of three Trustees, to be elected from time to time as vacancies occur by the members of the Institution at a General Meeting called for that purpose. All mortgages and other securities shall be taken in the names of such Trustees; and on any new appointment the funds shall vest in the newly-appointed Trustee or Trustees jointly with the continuing or remaining Trustee or Trustees.

vestment Funds.

46.—The Finance Committee may, with the consent of the Council, invest in the names of the appointed Trustees of the Institution any moneys not immediately required for the purposes of the Institution, in or upon any approved securities.

ALTERATIONS TO CONSTITUTION AND BYE-LAWS.

47.—Alteration in or addition to the Constitution and Bye-Laws may be made only by resolution of the members at the

Closing Business Meeting in May, after notice of the proposed alteration or addition has been announced at the previous General Meeting.

The resolution may be modified by the Council meanwhile, should they so desire; but in this case it shall be read at the Closing Business Meeting in May in its original form before it is proposed in the amended form.

Such resolutions shall be stated in the notice calling the intervening Council Meeting, and also in the notice calling the Closing Business Meeting in May.

Vote by Proxy.

Any member unable to be present at the meeting at which such alterations are to be considered, but who is nevertheless desirous of recording his opinion thereon, shall be allowed to vote by proxy, such proxies shall be in Form J in the Appendix, which may be had on application to the Secretary, and may be used by any member present at the meeting on behalf of the absent member, and counted by the Chairman as of equal value with votes given in the manner provided in Bye-Law 19.

THE GOLD MEDALS.

RULES.

1.—That papers read by members of the Council shall be eligible for the Gold Medals' Award.

2.—That the medals shall be awarded by the vote of the Council given at a meeting of the Council at which the business has been specially noted on the circular convening the meeting, and not by ballot papers previously sent out, as has hitherto been the custom.

3.—That when the Council proceeds to award the medals, authors of papers who are members of the Council shall not be present nor vote at such Council meetings.

4.—If at the meeting convened a quorum of the Council should not be present, or if the Council considers it desirable or cannot agree, the decision of the Council may be deferred and adjourned to a future meeting.

5.—That the medals shall be awarded annually, provided the papers are, in the opinion of the Council, worthy of the award, but not otherwise; and that they be awarded to the authors of the best papers, irrespective of their having previously obtained a gold medal.

APPENDIX TO BYE-LAWS.

FORM A. (BYE-LAW 1.)

Name (in full)
Profession or Occupation and where Employed
Address
being desirous of admission into the North-East Coast Institution of Engineers and Shipbuilders, we, the undersigned, propose and recommend that he shall become*
thereof. We know him to be†
and eligible for the proposed membership.

* Member, Associate, or Graduate.
† Principal, Manager, or Draughtsman, ‡ See Articles V., VI., and VII. Constitution.

	FROM PERSONAL KNOWLEDGE.	SECTION OF MEMBERSHIP
Proposed by		
Supported by Three Members or Associates.		

Dated this day of

(When a Graduate is proposed the age last birthday should be stated.)

FORM B. (BYE-LAW 2.)

A. B. [Christian Name, Surname, Occupation, and Address in full] being at present a Graduate of the North-East Coast Institution of Engineers and Shipbuilders, and upwards of twenty-four years of age, and being desirous of becoming a Member of the said Institute, we, the undersigned [Members or Associates], recommend him, from *personal knowledge*, as a person eligible for the proposed Change of membership, because—

(Here specify distinctly the Qualifications of the Candidate according to the spirit of the Rules of the Institution.)

Signed _____ } Three [Members or Associates.]
_____
_____

Dated this day of 19

FORM C. (BYE-LAW 3.)

BALLOTING PAPER FOR MEMBERSHIP.

The Council having considered the recommendations for Membership of the following gentlemen, present them to be balloted for, viz.:—

Member, Associate, or Graduate.	Occupation.	Address.	Nominated by.	Supported by Three Members or Associates.

Strike out the names of such persons as you desire shall *not* be elected, and forward the list by post to the Secretary, or personally place it in the ballot-box at the Meeting.

FORM D. (BYE-LAW 4.)

Sir,—I am directed to inform you that on the . . day of you were elected a of the North-East Coast Institution of Engineers and Shipbuilders, but, in conformity with Bye-Law 4, your election cannot be confirmed, nor your name be added to the roll of membership, until you have paid your first annual subscription, the amount of which is £ : : , or, at your option, the Life Composition of £ : : .

Payment may be made to the Treasurer, Mr._____

Address_____

I am, Sir,

Yours faithfully,

Secretary.

Dated 19

N.B.—In case of a Graduate, strike out "*or, at your option, the Life Composition of* £ : : "

FORM E. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to draw your attention to Bye-Law 6, and to remind you that the sum of £ of your annual subscriptions remains unpaid, and that you are in consequence in arrear of subscription.

I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

FORM F. (BYE-LAW 9.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-Law 9, the Council have determined that unless payment of the amount (£) is made previous to the day of next, they will proceed to declare that you have ceased to be a member of the Institution.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

FORM G. (BYE-LAW 10.)

SIR,—I am directed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inform you that they feel it their duty to advise you to withdraw from the Institution, or otherwise they will be obliged to act in accordance with Bye-Law 9 (or 10, as the case may be).

I am, Sir,

Yours faithfully,

Secretary.

FORM H. (BYE-LAW 11.)

BALLOTING LIST.

PRESIDENT.—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year (eligible for re-election.)*

——— }
——— } New Nominations, from whom to select ONE.
——— }

VICE-PRESIDENTS.—EIGHTEEN NAMES only to be returned (including the fifteen who remain in office), or the vote will be lost.

——— }
——— }
——— } Fifteen Vice-Presidents remaining in office. These do not require to be voted for at this election, as their term of service has NOT yet expired.
——— }
——— }

——— }
——— } Three Vice-Presidents retiring, eligible for re-election.
——— }

——— }
——— } New Nominations, from whom to select THREE.
——— }
——— }

TREASURER.—ONE NAME only to be returned, or the vote will be lost.

——— Treasurer for the current year, eligible for re-election.

——— }
——— } New Nominations, from whom to select ONE.
——— }

ORDINARY MEMBERS OF COUNCIL.—FIFTEEN NAMES only to be returned, including the ten who remain in office.

——— }
——— }
——— }
——— } Ten Ordinary Members of Council remaining in office. These do not require to be voted for at this election, as their term of service has NOT yet expired.
——— }
——— }
——— }
——— }
——— }

——— }
——— }
——— } Five Ordinary Members of Council retiring, and NOT eligible for re-election.
——— }
——— }

——— }
——— }
——— } New Nominations, from whom to select FIVE.
——— }
——— }
——— }

* To be crossed out before issue, when the President i not eligible for re-election.

N.B.—(*a*) The names of those who remain in office will be counted in the total number required without being re-written by the voter.

(*b*) Any list having either MORE or LESS than the required number of names voted for in any section will be disqualified for that section.

(*c*) Votes as President for a person who is not elected will count for him as a Vice-President.

(*d*) Votes as Vice-President, or Treasurer, for persons not so elected, will count for them as Ordinary Members of Council, unless they have just completed a term of office in that capacity.

(*e*) This list, duly filled in, may be returned to the Secretary by post, or handed to him, so as to be on the Council table before the commencement of the scrutiny, which is appointed to take place in the Council Room, at 8 p.m., on 19

(*f*) A copy of this list shall be posted at least Seven Days previous to the Annual Meeting to every Member and Associate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

Secretary.

FORM J. (BYE-LAW 45.)

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

FORM OF PROXY.

FOR VOTES ON ALTERATIONS TO CONSTITUTION OR BYE-LAWS.

I,....., being [an Honorary Member, Member, or Associate] of the above Institution, do hereby appoint Mr..... who is [an Honorary Member, Member, or Associate] of the same Institution, to act as my Proxy, and record my Vote at the General Meeting of the Institution, to be held on the... .....day of ....., 18....., and at any adjournment thereof.

Signature... .....

Address .....

....

.....*Secretary.*

I.—The Graduate Section shall be controlled by the General Bye-Laws of the Institution, and the following Bye-Laws are supplementary to these.

This Section shall be open to all Members of the Institution who are under twenty-six years of age, who shall be at liberty to express their views upon any subject brought before the General Meetings of the Section.

II.—The Officers of the Section shall be elected from and by the Graduates, in accordance with the Form given in the Appendix, and shall consist of one Chairman, one Honorary Secretary, and five Committee-men. The Committee shall have power to select one of its members to act as Assistant Honorary Secretary if required. **Officers by**

III.—(*a*) The Officers shall be elected annually, and shall all be eligible for re-election until the age limit is reached. **Election of Officers.**

(*b*) Any voting paper returning either more or less than one Chairman, one Honorary Secretary, and five Committee-men shall be disqualified. **Rider to General Bye-Law No. 11.**

IV.—The Annual General Meeting shall take place as early as possible after that of the Institution in the month of October, and the Closing Meeting shall be held prior to the Closing Business Meeting of the Institution in May. **General Meetings.**

V.—A Special General Meeting may be convened at any time by the Committee. The business discussed at such Special Meetings shall only be that indicated on the notice calling the meeting. **Special General Meetings.**

VI.—Nine Members shall constitute a quorum for the purpose of a General Meeting. **Quorum.**

VII.—Excursions shall be arranged during the Session as the Committee may find expedient. Any Graduate wishing to intro- **Excursions.**

duce a friend at such excursions must submit the name of his friend to the Committee at least three clear days before the date of the excursion.

Seven clear days' notice of every excursion shall be given to every Member of the Graduate Section.

COMMITTEE MEETINGS.

Committee Meetings.

VIII.—The Committee shall meet at as early a date as possible after the holding of a General Meeting, and on other occasions when the Chairman shall deem it necessary, being summoned in either case by circular, stating the time of meeting and the business so far as is known. All discussions of a personal character in the Committee shall be considered and treated as being strictly confidential.

Four members of Committee, including the Chairman, shall form a quorum.

Duties of Hon. Secretary.

IX.—The Honorary Secretary shall act under the direction and control of the Committee. He shall attend all Meetings, Committee and General, and shall take minutes of the proceedings and enter them in proper books provided for the purpose. He shall write the correspondence of the Graduate Section and Committee (excepting that arranging for excursions, which shall be arranged by the Secretary of the Institution). He shall keep a stamp account book, which on all occasions shall be open to the inspection of the Secretary of the Institution.

PAPERS.

Synopsis of Papers to be read.

X.—The author of a paper shall forward to the Honorary Secretary, at least fourteen days before the date of the reading of the paper, its title and a synopsis of the contents; a copy of the synopsis to be forwarded to every Graduate, together with the notice convening the meeting at which the paper is to be read.

Copies of Papers to be forwarded to the Secretary of the Institution.

XI.—After the reading of a paper a copy must be forwarded to the Secretary of the Institution in time to be placed before the Graduate Awards Committee. This copy, if deemed necessary by the Council, shall become the property of the Institution, and be placed upon the shelves in the Library. These copies, together with any sketches accompanying them, shall be written upon paper of uniform size.

APPENDIX.

GRADUATES' BALLOTING LIST.

CHAIRMAN.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

HON. SECRETARY.

*——— (E)
——— ( ) } Nominations from whom to select ONE.

COMMITTEE.

*——— (S)
*——— (EE)
*——— ( )
——— ( )
——— ( )
——— ( ) } Nominations from whom to select FIVE.

NOTES.

1.—Any list having either more or less than the required number of names will be disqualified.

2.—All voting papers must be returned to the Secretary of the Institution on or before the day of , 19 .

3.—No signature must be put on this paper.

4.—* Signifies a member of the old committee.

5.—(E) Denotes Engineer; (EE) Electrical Engineer; (S) Shipbuilder.

6.—A copy of this list shall be posted, at least fourteen days previous to the Closing Meeting of the Session, to every Graduate, who may erase any name or names from the list and substitute the name or names of any other person or persons eligible for such respective offices, but the number of persons on the list after such erasure or substitution must not exceed the number to be elected to the respective offices.

7.—Votes as Chairman or Hon. Secretary, for persons not so elected, will count for them as members of committee.

THE LIBRARY AND READING ROOM RULES.

Committee.

1.—The Library and Reading Room shall be managed by a Committee, called the Library Committee, who shall have charge of all books, papers, specimens, etc., which may belong to the Institution. It shall consist of five members of the Institution, of whom at least two shall be members of Council.

Property.

2.—The books and other property of the Library shall be vested in the Trustees appointed by the Institution.

Appointment of Committee.

3.—The Library Committee shall be appointed annually, at the first meeting of the Council in each Session. No member who has served on the Committee for three years in succession shall be eligible for re-election until after an interval of one year. The Chairman shall be elected by the Council.

Librarian.

4.—The Secretary of the Institution shall be Librarian, and shall also act as Secretary to the Library Committee. Three members of the Committee shall form a quorum.

Duties of Committee.

5.—The Library Committee shall be responsible for the binding and purchasing of books, periodicals, papers, etc., and for the expending of all money voted by the Council for its use. It shall appoint an attendant who shall act as Assistant Librarian. It shall make Rules for the management of the Library, subject to the approval of the Council, and present an annual report to the first meeting of the Council held after the annual scrutiny of the books referred to in Rule No. 13.

Hours of Opening and Closing, etc.

6.—Except when closed by special order of the Library Committee, or when the Council is sitting, the Library and Reading Room shall be open for consulting, borrowing, or returning books, every week day as follows:—

Monday	From 10 a.m. to 6 p.m., and from 7 p.m. to 9 p.m.
Tuesday	From 10 a.m. to 6 p.m.
Wednesday ...	From 10 a.m. to 6 p.m., and from 7 p.m. to 9 p.m.
Thursday ... ... / Friday	From 10 a.m. to 6 p.m.
Saturday	From 10 a.m. to 1 p.m., and from 3 p.m. to 9 p.m.

The Rooms will be closed on Christmas Day and the day following, New Year's Day and the day following, Good Friday and the day following, Monday and Tuesday in Easter week and Whit week, on Tuesday, Wednesday, Thursday, Friday and Saturday in the Race week of June, and the first Monday in August (being Bank Holiday); also from the second to the fourth Saturday in July of each year, as mentioned in Rule No. 13.

Lending Books.

7.—Books shall not be lent to any persons except Members, Associates, or Graduates of the Institution, but a person entitled to borrow a book may send a messenger with a signed order for it.

Visitors.

8.—Each member shall be entitled to introduce a friend to the Reading Room, whose name shall be written in the Visitors' Book, together with that of the member introducing him.

Reference Books.

9.—The books marked with an asterisk in the Catalogue shall be kept only for consultation in the Library, and shall not be lent. Pending the preparation of a Catalogue, the Librarian shall be instructed by the Committee as to which books shall be withheld from circulation.

Unbound Book

No periodicals, magazines, or pamphlets shall be issued for circulation until after they have been bound and added to the Lending Library.

Register of Books Lent, etc

10.—The Librarian shall keep a register in which he himself or the attendant shall enter the titles of the books lent, the date of lending, the name of the borrower, and the date of the return of the book to the Library. The borrower of the book or the bearer of his order shall initial the entry of such borrowing, and the Librarian or the attendant shall initial the date of the return of the book.

Number Lent t each member.

11.—No person shall borrow or have in his possession at one time more than two volumes belonging to the Library.

Return of Bool

12.—No member shall retain a book longer than fourteen days, excluding the day of issue. He shall be responsible for the safe return of the book, and if it be damaged or lost he shall make good the cost of such damage or loss.

Yearly Inspecti of Books.

13.—All books belonging to the Library shall be called in for inspection, and the lending out of books shall be suspended 'rom the second to the fourth Saturday of July, inclusive, of each ear, and members shall be required by notice to return all ɔoks in their hands before the period mentioned.

Fine

Members failing to comply with this injunction shall pay a fine of two shillings and sixpence.

14.—Members are requested, when in the Reading Room or Library, to contribute to the general comfort by carefully abstaining from loud talking and noise of any kind. Smoking is not permitted in the Library.

Members in Arrears.

15.—Any member being twelve months in arrears with his subscriptions to the Institution shall not be at liberty to use the Library or Reading Room after the commencement of the first Session following.

N.B.—The foregoing Rules may be amended at any time by the Library Committee with the sanction of the Council.

NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

The Sixteenth Session of the Institution was opened on the evening of the 20th day of October, 1899, with a conversazione and ball, at the invitation of the President (Sir Benjamin Chapman Browne, D.C.L., J.P.), and Lady Browne, in the Assembly Rooms, Westgate Road, Newcastle-upon-Tyne, and was attended by a large assemblage of ladies and gentlemen.

FIRST GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, NOVEMBER 3RD, 1899.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the Closing Business Meeting of last Session, held in Newcastle-upon-Tyne, on May 12th, 1899, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. R. H. Muir and Mr. B. C. Browne, Jun., to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Allan, James, Engineer, 39, Wellington Street, Blyth.

Allan, William, Jun., Engineer, c/o Messrs. Scotia Engine Works, Sunderland.

Blake, James, Engineer, Northbrooke, Linthorpe, Middlesbrough.

Brock, Henry W., Engineer and Shipbuilder, c/o Messrs. Wm. Denny & Bros., Dumbarton.

Barley, Wm. M. F., Foundry Manager, 14, Croft Terrace, Jarrow-on-Tyne.

Butterworth, George Herbert, Engineer, 53, Park Crescent, North Shields.

Denny, Leslie, Shipbuilder, c/o Messrs. Wm. Denny & Bros., Dumbarton.

Denny, Peter, Engineer and Shipbuilder, Bellfield, Dumbarton.

Fuller, Philip S., Engineer, 189, Cardigan Terrace, Gateshead-on-Tyne.

Giacomuzzi, Virgilio, Naval Architect, c/o Messrs. Nicolo Odero fu Alessandes, Sestri Ponenti, Italy.

Hall, Thomas, Engineer, 29, Selbourne Road, Ilford, London, E.

Macdonald, John C., Marine Engineer, c/o Messrs. Northumberland Engine Works, Wallsend-on-Tyne.

Marsden, John H. Wade, Engineer, 17, Harrison Place, Newcastle-upon-Tyne.

Maxwell, Thomas, Engineer, 15, Ashfield Terrace East, Newcastle-upon-Tyne.

McGillivray, Peter, Marine Engineer, 14, Normanton Terrace, Newcastle-upon-Tyne.

Menwissen, J., Ship Draughtsman, 18, Esplanade, Whitley Bay, Northumberland.

Robson, David M., Engineer, 10, West Park Terrace, South Shields.

Rutherford, Robt. T., Engineer, 34, Denmark Street, Gateshead-on-Tyne.

Sneddon, Alex. Russell, Surveyor, Lloyd's Register of Shipping, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Walker, Sept. H., Engineer, Denwick Street, Tynemouth.

Wilkinson, Thomas, Draughtsman, 9, Laburnum Avenue, Wallsend-on-Tyne.

GRADUATES TO MEMBERS.

Canning, Chas. E., Ship Draughtsman, c/o Messrs. Burmeister & Wains, Shipbuilders, Copenhagen, Denmark.

Craggs, Adolphus, Mechanical Engineer, Ivy House, Pelton, Chester-le-Street.

Dixon, William John, Engineer, H.M.S. "Renown," Mediterranean Squadron.

Hunter, George Ernest, Shipbuilder, The Willows, Jesmond, Newcastle-upon-Tyne.

Moroney, E. F., Marine Engineer, 180, Gloucester Road, Newcastle-upon-Tyne.

Robinson, Charles O., Engineer, Ingleside, North Shields.

Thomas, William, Foundry Manager, Holme House Foundry, Wigan.

ASSOCIATES.

Andersen, Andrew P., Shipowner, Haldane House, Jesmond, Newcastle-upon-Tyne.

Angus, John Chas., Engineer, c/o Messrs. Robt. Stephenson & Co., Ltd., Hebburn-on-Tyne.

Culley, F. I., Cashier, Northumberland Terrace, Tynemouth.

Hedley, Robert, Accountant, c/o Messrs. The Weardale Iron and Coal Co., Ltd., Tudhoe Iron Works, Spennymoor.

Hinchliffe, John, Accountant, 25, Hawthorn Street, Newcastle-upon-Tyne.

Hodges, Thomas Wm., Accountant, 86, Osborne Road, Newcastle-upon-Tyne.

Sisson, W. E., Secretary, Northumberland Terrace, Tynemouth.

Stephenson, George R., Cashier, Northumberland Engine Works, Wallsend-on-Tyne.

Thompson, Wm. H., Accountant, 5, Albany Gardens, Whitley Bay, Northumberland.

Wainford, Edgar H., Accountant, c/o Messrs. The Weardale Iron and Coal Co., Ltd., Tudhoe Iron Works, Spennymoor.

Willis, Thomas W., Shipowner, Stockton Road, West Hartlepool.

GRADUATES.

Blake, Lionel J. B., Draughtsman, 14, Woodhouse Terrace, Gateshead-on-Tyne.

Carnegie, Alfred Q., Electrical Engineer, 21, Eldon Place, Newcastle-upon-Tyne.

Crookston, David D., Engineer, 10, Hawthorn Grove, Wallsend-on-Tyne.

Cruickshank, Andrew, Engineer, 52, Tennant Street, Hebburn-on-Tyne.

Dewar, John, Engineer, The Green, Wallsend-on-Tyne.

Dilworth-Harrison, D. R., Electrical Engineer, 8, Belle Vue Terrace, Gateshead-on-Tyne.

Glahome, John W., Engineer, 43, North Terrace, Wallsend-on-Tyne.

Hammond, F. Chas., Draughtsman, Park Head, Jesmond Dene, Newcastle-upon-Tyne.

Jupp, William H., Draughtsman, 1, Grant Street, Jarrow-on-Tyne.

Kincaid, Thomas L., Engineer, 10, Hawthorn Grove, Wallsend-on-Tyne.

Luhrs, H., Engineer, 10, Lodge Terrace, Wallsend-on-Tyne.

Sprague, Cycil R., B.Sc., Engineer, 16, Wentworth Place, Newcastle-upon-Tyne.

Stagg, Albert E., Engineer, The Rectory, Willington-on-Tyne.

Straubenzee, H. T. V., Engineer, 6, First Avenue, Heaton, Newcastle-upon-Tyne.

Thomson, John, Ship Draughtsman, Wincombles House, Walker-on-Tyne.

White, Percy M., Engineer Draughtsman, c/o Messrs. Hawthorn, Leslie, & Co., St. Peter's Works, Newcastle-upon-Tyne.

The SECRETARY (Mr. John Duckitt) submitted the Council's Fifteenth Annual Report and Financial Statement.

The PRESIDENT delivered a short Address.

Mr. F. W. JENNINGS read a paper on "The Working Stress of Materials used in British Locomotive Construction."

COUNCIL REPORT.

(Fifteenth Session, 1898-99.)

The Council has pleasure in stating that the finances of the Institution are still in a satisfactory condition, but regrets to state that the subscriptions in arrear amount to £68 15s. 6d. Subscriptions are due in advance on the first day of August in each year, and if members would arrange to pay their subscriptions by the end of December, it would greatly assist the executive in carrying on the work of the Institution in a more regular and efficient manner.

The fifteenth session was opened on the 14th day of October, 1898, when the new President, Sir Benjamin C. Browne, delivered his inaugural address; and during the session the following papers were read and discussed :—

"Some Features of the Repairs and Construction of Iron and Steel Ships." By Mr. M. W. Aisbitt.

"An Improved Method of Strengthening Copper Steam Pipes." By Mr. T. Messenger.

"Works' Organisation." By Mr. Tom Westgarth.

"Some Considerations on Freeboard and on the Relation between Scantlings and Freeboard." By Mr. Archibald Hogg.

"Notes on the Manufacture of Shafting for Screw Steamers, with some causes of Defects and Failures." By Mr. E. C. Chaston.

"Remarks on the Increasing Frequency of Failure of Propeller Shafts." By Mr. Frank Caws.

"Shop and General Establishment Charges in Engineering Works, and their Relation to Costs and Estimates." By Mr. W. E. Cowens.

Two Gold Medals were awarded for the papers read before the Institution during the fourteenth session :—

The Shipbuilding Medal was awarded to Mr. A. Hogg for his paper on "The Comparison and Construction of Ships' Lines."

The Engineering Medal was awarded to Mr. A. L. Mellanby for his paper on "The Effects of Different Arrangements of Crank Angles upon the Economy of Quadruple Expansion Engines."

On the occasion of the Institution's visit to West Hartlepool on January 21st, 1899, Messrs. W. Gray & Co. kindly invited the members to inspect their Central Marine Engine Works. The visitors were cordially received by the officials. After the visit the members were most hospitably entertained by the firm.

The Institution Dinner was held in Newcastle-upon-Tyne on Friday, December 9th, 1898, and was well attended by members and their friends.

The term for which the representatives of this Institution had to serve on Lloyd's Technical Sub-Committee having expired, the Council was called upon to elect four representatives to serve for a further term of four years. Mr. W. Boyd and Mr. F. C. Marshall having declined to stand for re-election, Mr. John Tweedy and Mr. J. W. Reed were elected to take their place. Mr. Robert Thompson and Mr. H. Withy were also re-elected. The Report of the retiring members will be found on page 259 of volume xv. of the *Transactions.*

A communication having been received from the Board of Trade calling attention to the revised regulations proposed with regard to the examination of engineers in the Mercantile Marine, and desiring that these should be duly considered and reported upon, the Council gave the matter full consideration, and certain alterations and recommendations were forwarded to the Board of Trade which it was thought might prove beneficial.

The President, on behalf of the Institution, invited the Institution of Naval Architects to pay a summer visit to Newcastle-upon-Tyne, and other ports on the North-East Coast. This was cordially accepted, and the visit was duly paid during the month of July last.

Mr. C. H. Reynolds having left the district and resigned his seat on the Council, the Council has elected Mr. Ernest H. Craggs to fill his place.

Mr. H. S. Wallace having been obliged to resign his position as assistant librarian, the Council, as a mark of appreciation of his services during the ten years he has held the situation, has thought fit to make him a Life Associate of the Institution free of cost.

During the tenth session of the Graduate section eight meetings were held. The attendance at these meetings compared favourably with that of the previous session, but there is still room for improvement, and the Council hopes that the Graduate members will do their utmost to support this useful section of the Institution.

The session was opened by a most interesting address, delivered by the Chairman (Mr. R. Hinchliffe), on "Steamship Trials;" and during the session the following papers were read and discussed:—

"Lubrication." By Mr. F. W. G. Snook.

"The Longitudinal Strains of Ships." By Mr. H. B. Donaldson.

"The Selection of Continuous-current Electrical Plant for Power Transmission in Yards and Workshops." By Mr. James Brash.

"The Design and Equipment of Electrical Power Plant for Collieries." By Mr. Talbot Duckitt.

"The Modern Tendency of War-ship Design." By Mr. C. E. Canning.

"The Vacuum Automatic Brake." By Mr. F. W. Jennings.

The following places of interest were visited; and the thanks of the nstitution are due to the principals and officials of these establishments or the kindness and courtesy extended to the junior members:—

Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland.
" Palmer's Shipbuilding and Iron Co., Jarrow-on-Tyne.
" The Blyth Harbour Commissioners' Works, Blyth.

The following awards were presented to the authors of papers read efore this section during the ninth session:—

Books to the value of £4 to Mr. A. B. Binns for his paper on "The Air Pumps of Marine Engines."

Book to the value of £2 10s. to Mr. F. G. Rappoport for his paper on "Pattern Shop and Foundry Practice."

Books to the value of £1 1s. to Mr. R. Hinchliffe for his paper on "Some Notes on American Naval Architecture."

Mr. R. Hinchliffe has been re-elected Chairman, and Mr. W. H. Waddingham has been elected Honorary Secretary for the eleventh session.

During the year the following additions have been made to the list of nembers:—Life Member, 1; Members, 63; Graduates raised to Members, 21; Life Associate, 1; Associates, 8; Graduates, 35.

The Council regrets having to record the loss, by death, of the following:—Members: Mr. A. Ewen, Mr. W. C. Macdonald, Mr. J. Macgregor, Mr. W. Scotson. Associates: Mr. James Muir, Mr. James Wait. Graduate: Mr. W. H. G. Davison.

The Institution has lost, by resignations and other causes:—Members, 39; Associates, 7; Graduates, 12.

The total number of names now enrolled is as follows:—

Honorary Members	4
Life Members	7
Members	784
Life Associates	3
Associates	122
Graduates	118
Total	1,038

NORTH-EAST COAST INSTITUTION OF

STATEMENT OF RECEIPTS AND PAYMENTS

Receipts.

		£ s. d.	£ s. d.
To Balance from last Account—			
At Bank			350 17 2
„ Subscriptions received for Session 1898–99—			
248 Members at £2 2s.	£520 16 0		
506 Members „ £1 1s.	531 6 0		
123 Associates „ £1 1s.	129 3 0		
115 Graduates „ 10s. 6d.	60 7 6		
992		1,241 12 6	
„ Association of Foremen Engineers and Draughtsmen—			
One year's Subscription		20 0 0	
„ Life Member—A. Harrison, Esq.		21 0 0	
„ Subscriptions received in advance		9 9 0	
„ Arrears from Sessions 1892–98—			
7 Members at £2 2s.	£14 14 0		
24 Members „ £1 1s.	29 8 0		
(including 2 years' arrears paid by four of these members)			
3 Associates at £1 1s.	3 3 0		
4 Graduates „ 10s. 6d.	2 2 0		
		49 7 0	
			1,341 8 6
„ Transactions sold this Session		35 13 4	
„ Copies of Members' Papers supplied		7 15 6	
			43 8 10
„ Tyne Improvement Commissioners—			
One Year's Interest to 21st June, 1899, on £605, at 3⅝ per cent.		21 18 6	
Viz.:—Medal Fund	£274 0 0		
Graduates' Award and Life Members' Fund	331 0 0		
Less—Tax		0 14 5	
			21 4 1
One Year's Interest to 10th July, 1899, on £500, at 3¾ per cent.		18 15 0	
Less—Tax		0 12 6	
			18 2 6
One year's Interest to 4th May, 1899, on £300, at 3 per cent.		9 0 0	
Less—Tax		0 6 0	
			8 14 0
Half-Year's Interest to 13th July, 1899, on £300, at 3¼ per cent.		4 17 6	
Less—Tax		0 3 3	
			4 14 3
			£1,788 9 4

ENGINEERS AND SHIPBUILDERS.

FOR SESSION ENDING 31ST JULY, 1899.

Payments.

	£	s.	d.	£	s.	d.
By Transactions and Papers—						
Lithographing	34	12	0			
Printing and Binding	192	13	2	227	5	2
„ Stationery and Circulars	72	0	6			
„ Reporting	28	10	6			
„ Rents—						
Offices and Electric Light Fittings	112	12	9			
Lecture Rooms	7	4	0			
Telephone	8	0	0	228	7	9
„ Rates, Gas, Electric Light, and Insurance...				28	6	0
„ Salaries—						
Secretary, Salary	340	0	0			
„ Commission	66	1	4			
Assistants'	45	15	0			
„ Postages, Stamps, Post Cards, Parcels, etc.	94	19	9			
„ Secretary's Expenses and Allowances to Hall Keepers, etc.	42	15	8			
„ Office Expenses, Coals, Cleaning, etc.	21	4	0			
„ Measured Mile Posts—Rent...	6	6	0			
„ Auditor's Fee	5	5	0			
„ Lantern Expenses	2	16	6	625	3	3
„ Library Account—						
New Books	8	11	0			
Bookbinding	12	0	10			
Additions to Transactions	2	16	0	23	7	10
„ Gold Medals' Fund—						
Two Gold Medals awarded				11	0	0
„ Graduates' Award Fund—						
Amounts awarded for Papers				7	11	0
„ Tyne Improvement Commissioners—						
Investment at 3¼ per cent. per annum				300	0	0
„ Balance at Bank				337	8	4
				£1,788	9	4

THE BALANCE SHEET FOR SESSION ENDING 31ST JULY, 1899.

Liabilities.

		£ s. d.	£ s. d.
Gold Medals' Fund—			
Amount at 31st July, 1898 ..	£292 11 11		
Interest on Investment ...	9 12 1		
		302 4 0	
Less—Two Medals awarded		11 0 0	
			291 4 0
Graduates' Award Fund—			
Amount at 31st July, 1898 ...	£223 6 2		
Interest on Investment ...	7 11 3		
		230 17 5	
Less—Awards for Papers		7 11 0	
			223 6 5
Payments by Life Members and Associates—			
Amount at 31st July, 1898		189 0 0	
Add—Life Member this Session ...		21 0 0	
			210 0 0
Subscriptions paid in advance			9 9 0
General Capital			2,019 16 4
			£2,753 15 9

Audited and certified,
R. W. SISSON, F.C.A.

Newcastle-upon-Tyne,
12th October, 1899.

Assets.

		£ s. d.	£ s. d.
Subscriptions in Arrear—			
Session 1897-98		5 15 6	
„ 1898-99		63 0 0	
			68 15 6
Stock of Transactions, valued at			191 9 9
Office and Library Furniture, Safe, etc., as at 31st July, 1898		150 5 10	
Less—Depreciation		15 0 6	
			135 5 4
Books in Library—			
As at 31st July, 1898 ...	£294 14 6		
Less—Depreciation ...	29 9 6		
		265 5 0	
Additions this Session—			
Purchases		20 11 10	
Books received in exchange for Transactions		30 0 0	
			315 16 10
Tyne Improvement Commissioners—Investment in respect of the following Accounts, viz.:—			
Gold Medals' Fund		274 0 0	
Graduates' Award Fund		215 15 0	
Payments by Life Members and Associates		115 5 0	
General Capital—			
As at 31st July, 1898 ...	£800 0 0		
Add—Investment at 3¼ per cent.	300 0 0		
		1,100 0 0	
			1,705 0 0
Cash—At Bank			337 8 4
			£2,753 15 9

The PRESIDENT proposed that the report and balance sheet be approved. He had no remarks to make of any importance. He thought they had had a successful year, and one felt more and more the great value of an Institution of this sort in the district. Speaking from a purely practical point of view, the only thing he would mention was this fact. They had had, as they knew, a visit from the Institution of Naval Architects. When he was a young man their ambition used to be to become associates or members of the Institution of Civil Engineers. There was no doubt that the engineering world was now getting more subdivided, and to marine engineers and shipbuilders the Institution of Naval Architects holds the position that used to be held by the Institution of Civil Engineers towards the whole profession. He thought it desirable that they should all bear in mind that this Institution ought to be more and more closely connected with the Institution of Naval Architects, and that they should gradually look forward to becoming members of both bodies. He thought on the whole the report was satisfactory, and he had great pleasure in moving its adoption.

Mr. J. R. FOTHERGILL seconded the adoption of the report and balance sheet. He did not think there was much to say. He should like to draw the attention of the meeting to the fact that they were again in the unhappy position of having to cross out the names of several members who had not paid their subscription. He wished to draw attention to this most unsatisfactory condition. Arrears amounting to £68 15s. 6d. was a very serious matter. He found it very difficult to offer any explanation. It was an annual deficit which he was afraid they could not surmount. He also wished to draw their attention, and he hoped that of others than those present, to the Council's expression of opinion that it is desirable that all subscriptions should be paid before the end of December. This was very desirable for financial reasons and auditing of accounts. It must be very satisfactory to find that they had such a total number of members as over a thousand, and to note the additions that evening. So far as the balance sheet was concerned, he thought that the condition of the funds must be very satisfactory to the members. They would find from this balance sheet that they had a sum of something like £1,200 invested and about £337 at the bank, so if they took the years the Institution had been in existence they would feel they were in a very sound position. They would note that the business-like course was taken of writing off against value of

stock, material, etc., 10 per cent., which he was sure they would all agree to.

The report and balance sheet were approved *nem. con.*

THE PRESIDENTIAL RECEPTION AND BALL.

Mr. G. F. MULHERION, obtaining the hearing of the meeting, said he thought it was only right that they, at their first meeting, should make their acknowledgments to the President and Lady Browne for the very kindly, courteous, and hospitable manner in which they had received them a fortnight ago. There were about 600 people present, and he for one—and he was sure he echoed the opinion of everybody present on that occasion—enjoyed a very happy evening indeed, and he thought he was only voicing the feelings of all in moving a very hearty vote of thanks to the President and Lady Browne for their kindness.

Mr. J. R. FOTHERGILL had very great pleasure in seconding the vote of thanks, so well proposed to the President and Lady Browne. He did not think he could add to the expressions already made with regard to that pleasant and sociable occasion. He was perfectly sure that the whole of the members of this Institution, and particularly those gentlemen and ladies who were present, appreciated most fully, most thoroughly, and in every sense of the words, the hearty and genial reception they had had that evening.

Mr. MULHERION put the vote to the meeting, and it was carried by acclamation.

The PRESIDENT, speaking for Lady Browne and himself, was very grateful for their kind expressions. It was a great pleasure to see their friends around them, and he was sure as long as the trade of the North-East Coast continued they would find plenty of the older members willing to fill the office of President, and be glad to give their friends an opportunity of enjoying themselves. For such a gathering to give pleasure several things were necessary; not only must the gathering be pleasant in itself, but very much depended upon the work of his kind friends—Mr. Duckitt and the stewards—and on the friendly spirit of the guests. It was a real pleasure to him to think that they, who were striving to make their living in competition with each other, were also sincere friends and had great pleasure in meeting together socially for their mutual enjoyment.

PRESIDENT'S OPENING REMARKS.

The PRESIDENT did not know that any opening remarks were expected from him this session. The Institution was prospering, and although trade varied, being sometimes good and sometimes bad, their Institution went on steadily. Trade might come and trade might go, but this Institution went on, ever getting more prosperous. That was as it ought to be. They lived in times when young engineers, to get on, must be scientific, keen, and practical. He supposed that, speaking generally, it was not harder for a man to earn a living now than ever it was; but unless a man was keen and enthusiastic, there was very little place for him in a country where work was carried on at such high pressure as in England. It came to this, that men must take up their trades and industries in such a way that they really found a pleasure in them, that the work was not a task to which they went in the spirit implied by that sickening expression sometimes used when people talked of the working classes as "sons of toil," as if toil were an evil. Why they would be bored to death if it were not for toil. Work should be the pleasure of life as well as the discipline of character. If you tell a man he is "a son of toil," it is like telling him, "Oh, your work is dreadful." Is the ideal of happiness to be sitting on a wall, smoking a pipe, doing nothing? Does anyone look upon the life of the "loafer" as the highest ideal of human happiness? One reason for this Institution is to bring young men—and old men, too, for that matter—to take an interest and feel what an amount of pleasure there is not only in studying their profession, but in pitting their wits against each other in the friendly duel that comes from intellectual fencing and sparring, tending to smarten them up and make them more and more fit for the work they had to do. He thought there was a point which young and old ought to realise, that to succeed in their practical and professional work alike it must be divided into three distinct businesses. He spoke, of course, to a body of whom the majority were in a position where they had to make something, which then had to be sold to somebody else for his use; in fact, he should speak to them as scientific manufacturers. First of all, there was what they might call the full development of the draughtsman's work—that was designing the best possible article. Of course, that required a high scientific knowledge and also practical experience. The second thing was a full development of the foreman's work—the making of the article, the manufacturing of it in the best and cheapest way.

The third was to know and where to sell it. He would not dwell on the third, but would say a few words as to the second. A man might be able to manufacture an article well without being able to design it well. The two things, although touching at many points, in many ways, were distinct, and a man might be good at one without being good at the other. They would see that at once if they looked to any large work. Take the making of a railway. They had the consulting engineer, who made all the surveys, designs, and calculations for the new line. Then they came to the railway contractor. Now, the contractor was quite a different man to the engineer, so different that in the old-fashioned days of the civil engineers they did not consider one who was simply a contractor worthy of being a full-blooded member of their Institution. He (the President) thought they were wrong, for it was just as difficult to make a railway as to draw it on paper. There were special qualities required for both—the one was the full development of the draughtsman's business, and the other of the foreman's business. Now, in the third place, however scientific might be their design, they must not shut their eyes to the possibility of selling the article when made. It had been said that "any fool"—that was a strong word, but he was not prepared to object to it—"any fool could do good engineering work if he did not care how much it cost." If a man could go over and over again he was sure to stumble upon the right thing at last; but the thing was to be able to do good work right off without hesitation of any kind. There ought to be no bad designing at all. In this connection he pointed to what was known as "standardisation"—the duplication of a given article over and over again, instead of having each altered or interfered with by the introduction of some fad of the customer. First make your article as perfect as possible, and in the open market say that was the article you had to sell. In the case of the ordinary machinery of their ships they certainly did that in nine cases out of ten. If they were going to buy an article like a locomotive engine, what they should do would be to find a man who made something like the standard article you want. They must know it had not only been carefully thought out, but also that, having been often made and worked all its weak points had been found out, ascertained, and rectified. If a man made a new design of anything, he found things here and there had to be put right, and it was far better when they designed a new type to do so when it was not wanted and find out the weak points before it was wanted; otherwise, when one designed a thing in a hurry there might be some trumpery objection raised because a small thing

went wrong, and brought discredit upon the whole job. The thing he impressed upon them was this: there ought not to be any bad designing ever done. Much better was it to take one article, study what everybody else knew about it, find out what the best people in the world had found out, and go a step further, then they made a really perfect design. He had been taught very early in life that the first important thing for a young apprentice going into a shop was to know good work from bad work. When once their eyes got used to really good work they would never be satisfied with bad work. When people said to him, "Where do you advise me to send my son?" he invariably said, send him where he will see really good work. This standardisation was the keynote with which the Americans had cut so seriously and so successfully into their trade. In some cases standardisation could not be adopted to get the best results. In a few cases it was quite worth while to have each article carefully designed so as to arrive at a special degree of excellence. Remember this, however, when they differed from existing types they did so because it was worth while even at a far higher cost to give a greater amount of labour to reach something altogether above the normal. However humble their position, whatever they made, whatever they did, whatever their sphere was, they ought to feel they were striving to do some fraction of engineering work better than any other human being could do it.

THE WORKING STRESS OF MATERIALS USED IN BRITISH LOCOMOTIVE CONSTRUCTION.

By F. W. JENNINGS.

[Read before the Institution, in Newcastle-upon-Tyne, on November 3rd, 1899.]

One of the most difficult problems in designing any class of machinery is the determination of the proper working stress of the various parts, and to no class of machinery does this apply with more force than to the locomotive. The complex strains to which many of the parts are subjected, caused by running at high speeds over uneven roads, the fact that the boiler is part of the moving machine, the necessity for carrying the whole structure on springs, and various other reasons, all tend to render the conditions and stresses more than ordinarily involved. While this is the case, there is probably no machine which has been more neglected by scientific men in this country. The writer does not know of any engineering college in Great Britain with an experimental locomotive, but in America there are several, upon which many useful experiments have been made.

With the object of being of some assistance to the designers of locomotives, and also of inducing some of the many able members of this Institution to take an interest in the subject, the writer has investigated the stresses usually allowed on some of the more important parts of the locomotive.

Piston Rods.

The material most commonly used for piston rods is either crucible cast steel or hard Siemens steel, the ultimate tensile strength varying from 30 to 50 tons per square inch, with an elongation of about 25 per cent. on 2 inches. The most common form of rod is that fitted with a separate crosshead, the end of the rod being slightly reduced to fit into this. This design enables the glands, bushes, and packing to be used without cutting in two parts. In British engines the rods are generally increased in diameter where they fit into the piston, and have a taper of about 1 in 6. Many rods are also increased in diameter at the cross

head end, whilst others have the crosshead forged solid. These designs are preferable from many points of view to the other, the great objection to them being that they necessitate the glands, bushes, and packing being cut into two parts to enable them to be passed over the raised part of the rod.

The stress allowed per square inch of net area through the crosshead keyway or at the bottom of the thread does not as a rule exceed 9,000 lbs. per square inch, and although the writer has found instances of stresses as high as 12,000 lbs. standing satisfactorily, he thinks 9,000 lbs. should be the limit. The tensile stresses obtained on the main part of the rods varied from 4,000 lbs. to 8,000 lbs. A limit of 6,000 lbs. is probably most satisfactory and will give sufficient allowance for wear. Upon investigating the liability to buckle by treating the rods as columns with fixed ends the stresses were found to vary from 5,000 lbs. to 8,000 lbs., consequently any stress below 7,000 lbs. may be considered safe. The keys are generally made of somewhat harder material than the rods, and the shearing stresses, calculated for single shear, were found to vary from 9,000 lbs. to 15,000 lbs., the safe limit may therefore be put down as 14,000 lbs.

Coupling Rods.

The majority of coupling rods are now made of best Siemens steel, having a tensile strength of 30 to 35 tons per square inch and an elongation of about 30 per cent. on 2 inches, the rods being forged solid without weld. Several locomotive superintendents, however, still prefer to use Yorkshire iron, having a tensile strength of about 24 tons, with an elongation of about 25 per cent. on 10 inches. By far the greatest stress on coupling rods is due to the centrifugal force when running at high speeds. For the purpose of comparison the writer has adopted a standard of 350 revolutions per minute, this being equivalent to an engine with a wheel 6 feet diameter going at 75 miles per hour, and all the stresses mentioned due to the centrifugal force are calculated for this speed. Other stresses are produced by the push and pull of the piston, the variation in the length of rod due to the wear of brasses, and by the unequal adhesion of the coupled wheels, but it is impossible to calculate the stresses due to the last two causes. It may be safely assumed that the maximum stress due to the push or pull of the piston does not occur in combination with the maximum stress due to the centrifugal force. For four-wheel coupled engines the load for tension and column calculations has been taken as half the total piston thrust and for six-wheel

coupled as one-third. Many rods are now made I section, this being superior to the rectangular section, owing to its greater strength for an equal weight. The stresses due to centrifugal force vary from about 10,000 lbs. to 18,000 lbs. for four-wheeled coupled engines, and from 9,000 lbs. to 17,000 lbs. for six-wheeled coupled. Any stress below 16,000 lbs. may therefore be considered safe for either four or six-wheel coupled engines. The tensile stresses vary from 2,000 lbs. to 4,000 lbs., and stresses as columns with fixed ends tending to buckle horizontally or with round ends tending to buckle vertically vary from 2,000 lbs. to 6,000 lbs.

Connecting Rods.

Connecting rods are usually made of similar material to the coupling rods, the I section being used for the long rods on many outside cylinder engines, such as those recently adopted on the North Eastern and Great Northern Railways, whilst the solid rectangular section is still retained for the shorter rods on inside cylinder engines. The chief stresses are produced by the push and pull of the piston, and by the centrifugal force caused by the large end whirling round the crank. Unlike the coupling rods these stresses are not increased to any appreciable extent by unequal adhesion or variation in length due to wear, etc., therefore the stresses allowed are considerably higher. To obtain the centrifugal force at the centre of the rod, the writer described the ellipse formed by a point at the centre of the rod; an approximate radius was then found for the top curve of this ellipse, this radius being used in the centrifugal force formula. The velocity was assumed to be the same as at the end of the rod. Thus for a crank pin path of 26 inches diameter this radius was found to be about 25 inches, and the formula $\frac{WV^2}{GR}$ became

$$W \times \frac{[2{\cdot}166 \times 3{\cdot}1416 \times 5{\cdot}833 \text{ (revolutions per second)}]^2}{32 \times 2{\cdot}083}.$$

The tensile stresses obtained varied from 5,000 lbs. to 7,500 lbs., stresses as columns with fixed ends tending to buckle horizontally from 6,000 lbs. to 13,000 lbs., or with round ends tending to buckle vertically 5,000 lbs. to 10,000 lbs., the highest stresses being on the rods of I section. The stresses due to centrifugal force varied from 5,000 lbs. to 11,000 lbs. The whole of the stresses given for coupling and connecting rods are on the main part of the rods, the stresses through the straps, etc., being ignored.

Crank Pins.

Crank pins are made of either Siemens steel with tensile strength varying from 30 to 40 tons and elongation from 25 to 30 per cent. on 2 inches; of Yorkshire iron, tensile strength about 24 tons with elongation about 25 per cent. on 10 inches; or of Whitworth fluid compressed steel, tensile strength about 36 tons with elongation about 25 per cent. on 2 inches. The stresses on crank pins for inside cylinder engines, or on driving crank pins for outside cylinder engines, on which the connecting rod is next to the wheel, *i.e.*, inside the coupling rod, are infinitesimal, the sizes being determined almost entirely by the bearing surface. The writer has, therefore, confined his attention to the driving crank pins for outside cylinder engines on which the connecting rod is outside the coupling rod, this being necessarily the case on all six-wheel coupled engines, and to trailing crank pins for outside cylinder engines upon which the connecting rod is inside the coupling rod. It has been assumed that the total piston thrust is uniformly distributed amongst the coupled wheels. Thus, in the case of a driving crank pin for a six-wheel coupled engine the primary bending moment due to piston thrust is $\frac{1}{3}$ total piston thrust multiplied by distance from centre of connecting rod journal to wheel face, the counter bending moment due to the support of the coupling rod being $\frac{2}{3}$ piston thrust multiplied by distance from centre of coupling rod journal to wheel face. In the case of a four-wheel coupled engine, the $\frac{1}{3}$ and the $\frac{2}{3}$ each become $\frac{1}{2}$. By deducting the counter bending moment from the primary bending moment the actual bending moment is obtained, from which the stress can be easily calculated. The stresses thus [illegible] vary from 10,000 lbs. to 17,000 lbs., and any stress below [illegible] may be considered safe for any of the [illegible]

Side Bars.

Side bars are generally made of [illegible] Siemens [illegible] cylinder, [illegible] have [illegible] moment [illegible]

[illegible]

sufficient allowance for wear. On several railways the bars are supported at the centre, the London and South Western Railway supporting them in this manner, and making them of cast iron. This type has been ignored, as it is impossible to compare them with those of ordinary type.

Driving Axles for Outside Cylinder Engines.

These axles are generally made of Bessemer or Siemens steel, the tensile strength varying from 28 to 38 tons, with an elongation of from 25 to 35 per cent. The chief stresses on them are the bending stress due to the load on journal, the torsional stress caused by the unequal adhesion of the wheels, and the bending stress caused by the centrifugal force, when going at high speeds round curves. As the writer has not sufficient particulars to calculate the last stress, it has been ignored. When running at high speeds over uneven roads, there will probably be other stresses which it is quite impossible to calculate. It has been assumed that the piston thrust is uniformly divided amongst the coupled wheels. Thus, in a six-wheel coupled engine, the bending moment due to piston thrust is $\frac{1}{3}$ piston thrust multiplied by the distance from centre of connecting rod bearing to centre of axle box journal, and the bending moment due to load on journal, the load multiplied by the distance from centre of journal to centre of rail. As these stresses are at right angles to each other, we get, calling the resultant C, and the stresses A and B respectively, $C = \sqrt{A^2 + B^2}$. It is not probable, under any circumstances, that more than half the twisting moment is transmitted through the axle. This, therefore, becomes: $\frac{\text{half piston thrust} \times \text{length of crank}}{2}$. Having obtained the bending stresses A and B, the resultant C, and the torsional stress T, the total resultant is $\frac{C}{2} + \sqrt{\frac{C^2}{4} + T^2}$. The total resultant stresses obtained in this manner vary from 7,000 lbs. to 10,000 lbs. on new axles, and from 8,000 lbs. to 12,000 lbs. with journals worn half an inch. Therefore, stresses of 8,000 lbs. and 10,000 lbs. respectively may be considered good practice.

Crank Axles.

Crank axles are usually forged from best Siemens steel, the tensile strength varying from 30 to 35 tons, with an elongation of from 30 to 35 per cent. on 2 inches. To obtain the maximum stress at the centre of the axle, the writer has assumed that it is possible for the maximum

piston thrust of both cylinders to be transmitted to the axle at the same time; thus to obtain the bending stress due to piston thrust the axle has been treated as a beam supported, the centre of bearings being the centre of supports and loaded at two points, viz., the centres of cranks. To obtain the torsional stress he has assumed that half the total twisting moment due to one crank is transmitted through the axle. By combining these two stresses with the bending stress due to load on journals resultant stresses at centre of axle varying from 9,000 lbs. to 13,000 lbs. were obtained, and a stress of 11,000 lbs. may be considered good practice. The stresses on the journals were obtained in a similar manner to those for straight axles, it being assumed, however, that the total load due to piston thrust is transmitted through the axle instead of being immediately divided amongst the coupled wheels. The total resultant stresses obtained varied from 7,000 lbs. to 11,000 lbs. on new journals and from 9,000 lbs. to 13,000 lbs. with journals worn half an inch. Stresses of 9,000 lbs. and 11,000 lbs. respectively may therefore be considered good practice.

In conclusion, the writer must express his great indebtedness to the following locomotive superintendents who have given him so much valuable information: W. Worsdell, Esq., North Eastern Railway; H. A. Ivatt, Esq., Great Northern Railway; J. F. McIntosh, Esq., Caledonian Railway; D. Drummond, Esq., London and South Western Railway; W. F. Pettigrew, Esq., Furness Railway; and L. Longbottom, Esq., North Staffordshire Railway.

[illegible] the following tables [illegible] found six examples of stresses on each [illegible] details mentioned [illegible] the paper the whole being taken from [illegible] Brunswick main lines. The calculations for the first [illegible] in each table are also given in detail.

[illegible] will prove interesting to the [illegible] this institution and that they will [illegible] a long and [illegible]

Piston Rods.

Total Load.	Centre of Piston to Centre of Crosshead.	Diameter at Centre.	Diameter of Screw.	Number of Threads per Inch.	Cross-section through Keyway.	Cross-section of Key.	Tensile Stress at Centre.	Stress as Column.	Tensile Stress at Bottom of Thread.	Tensile Stress through Keyway.	Shearing Stress on Key.
Lbs.	Inches.	Inches.	Inches.		Sq. Inches.	Sq. Ins.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
40,750	49	3	$2\frac{7}{8}$	6	6·1	1·48	5,770	6,800	7,330	6,690	13,760
40,900	48	3	$2\frac{3}{4}$	6	4·942	1·6	5,800	6,600	8,120	8,300	12,790
49,600	62	$3\frac{1}{2}$	3	4	6·265	1·99	5,160	5,870	8,790	7,920	12,460
38,170	$46\frac{1}{4}$	3	$2\frac{3}{4}$	6	3·281	1·328	5,400	5,960	7,570	11,600	14,350
49,600	45	$3\frac{1}{4}$	$2\frac{3}{4}$	7	—	—	5,980	6,500	9,580	—	—
47,040	42	3	$2\frac{1}{2}$	7	—	—	6,660	7,230	11,200	—	—

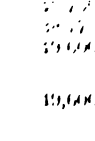
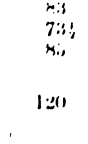
Coupling Rods. Four-wheel Coupled Engines.

Total Piston Thrust. L.	Load for Tension and Column Calculation. $\frac{L}{2}$	Length.	Section at Ends.	Section at Centre.	Diameter of Crank Pin Path.	Total Weight of Rod minus Ends.	Centrifugal Force at 350 Revolutions per Minute.	Tensile Stress.	Stress as Column Horizontally.	Stress as Column Vertically.	Stress due to Centrifugal Force.
Lbs.	Lbs.	Inches.	Ins. Ins.	Ins. Ins	Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
34,050	17,025	94	$3\frac{3}{4} \times 1\frac{1}{2}$	$4\frac{1}{2} \times 1\frac{1}{2}$	22	166	6,400	3,030	5,820	3,990	14,850
47,040	23,520	120	$5\frac{1}{4} \times 1\frac{3}{4}$	$5\frac{1}{4} \times 1\frac{3}{4}$	18	312	9,830	2,560	6,580	4,340	18,380
40,900	20,450	99	$4\frac{1}{4} \times 1\frac{1}{2}$	$4\frac{3}{4} \times 1\frac{5}{8}$	20	194	6,800	3,310	5,920	4,180	13,750
38,170	19,085	102	$4\frac{1}{4} \times 1\frac{5}{8}$	$4\frac{3}{4} \times 1\frac{5}{8}$	22	223	8,580	2,470	5,730	3,990	17,900
49,600	24,800	82			23	154	6,190	4,200	6,480	4,490	10,170
49,600	24,800	111			20	260	9,120	3,480	5,330	4,030	12,000

Coupling Rods. Six-wheel Coupled Engines.

[illegible]	[illegible]	Length Coupled End	Length Solid End	Centre of Driving Crank Pin to Centre of Coupling Pin	Section at Ends	Section at Centre	Diameter of Crank Pin Path	Weight Coupled End.	Weight Solid End.	Centrifugal Force of Coupled End at 350 Revolutions.	Centrifugal Force of Solid End at 350 Revolutions.	Tensile Stress.	Stress as Column Coupled End.	Stress as Column Solid End.	Stress due to Centrifugal Force Coupled End.	Stress due to Centrifugal Force Solid End.
Ins.	Ins.	Ins.	Ins.	Ins.	Ins. × Ins.	Ins. × Ins.	Ins.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
[illegible]	11,350	82	94	6	3¼ × 1½	4½ × 1½	22	133	166	5,120	6,400	2,330	3,120	3,880	9,590	14,850
[illegible]	[illegible]	108	90	6¾	3½ × 1½	4 × 2	18	188	167	5,900	5,250	2,980	3,640	3,280	13,990	11,070
[illegible]	[illegible]	99	87	6	4¼ × 1½	4¼ × 1½	20	167	157	5,750	5,410	2,130	4,870	4,530	14,800	13,000
[illegible]	[illegible]	99	87	6	4¼ × 1½	4¼ × 1½	22	167	157	6,440	6,050	2,260	5,160	4,770	16,600	14,550
[illegible]	[illegible]	93	93	7½	4½ × 1¼	4½ × 1½	22	168	182	6,480	7,020	1,835	3,820	4,180	12,950	15,200
[illegible]	[illegible]	108	93	6¾	3¼ × 1⅞	4¼ × 1¼	20	215	197	7,550	6,920	2,040	3,560	3,280	16,950	14,230

Connecting Rods.

[illegible]	[illegible]	Length	Section, Small End	Section, Large End	Radius for Centrifugal Force Formula.	Total Weight of Rod minus Ends.	Centrifugal Force at 350 Revolutions per Minute.	Tensile Stress.	Stress as Column Horizontally.	Stress as Column Vertically.	Stress due to Centrifugal Force.
Ins.	Ins.	Ins.	Ins. × Ins.	Ins. × Ins.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
[illegible]	23	72	3 × 1⅞	4¼ × 1⅞	23	138	3,020	7,000	7,830	7,350	6,220
[illegible]	26	78	3½ × 2	5 × 2	25	187	4,420	6,720	8,350	8,040	7,150
[illegible]	23	83	3¾ × 1 11/16	5½ × 1⅞	27	193	4,800	6,450	8,550	7,090	7,840
[illegible]	26	73½	3¼ × 2	5 × 2	25	171	4,040	5,870	6,700	6,580	6,550
[illegible]	26	85	3¾ × 2	5¼ × 2	25	216	5,110	6,620	8,830	8,150	8,040
19,000	21	120			23	290	6,370	6,960	13,100	10,200	10,800

Crank Pins for Outside Cylinder Engines.

Total Piston Thrust.	No. of Wheels Coupled.	Diameter of Crank Pin.	Centre of Connecting Rod Journal to Wheel Face.	Centre of Coupling Rod Journal to Wheel Face.	Primary Bending Moment due to Piston Thrust.	Counter Bending Moment due to Coupling Rod.	Actual Bending Moment.	Stress.
Lbs.		Inches.	Inches.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.
45,300	6	$5\frac{3}{4}$	8	$2\frac{3}{8}$	362,400	71,800	290,600	15,620
32,200	6	5	$7\frac{3}{4}$	$2\frac{3}{4}$	249,700	59,030	190,670	15,530
49,600	4	6	$5\frac{1}{2}$	$1\frac{1}{2}$	272,000	37,150	234,850	11,080
33,100	4	$4\frac{1}{2}$	$4\frac{3}{4}$	$1\frac{3}{8}$	157,200	22,750	134,450	15,050
47,040	4	$5\frac{1}{2}$	—	$6\frac{7}{8}$	—	161,500	161,500	9,900
35,610	4	5	—	$7\frac{3}{4}$	—	138,000	138,000	11,250

Slide Bars.

Total Piston Thrust.	Length of Connecting Rod.	Length of Crank.	Number of Bars per Cylinder.	Load on Bars.	Centres of Bolts.	Width.	Depth.	Stress.
Lbs.	Inches.	Inches.		Lbs.	Inches.	Inches.	Inches.	Lbs.
34,050	72	12	4	5,675	$45\frac{1}{2}$	$2\frac{1}{2}$	2	19,350
40,900	69	13	4	7,720	$48\frac{3}{4}$	3	$2\frac{1}{4}$	18,600
38,170	$73\frac{1}{2}$	13	4	6,750	$37\frac{3}{8}$	$2\frac{1}{4}$	$2\frac{1}{4}$	18,650
40,750	83	14	2	6,870	$49\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{5}{8}$	14,100
45,300	$101\frac{3}{4}$	13	1	5,800	49	6	$2\frac{3}{4}$	9,400
40,320	$108\frac{1}{2}$	13	1	4,830	49	6	$2\frac{5}{8}$	8,600

Driving Axles for Outside Cylinder Engines.

							New Axles.					Journals Worn ½ Inch.				
Total Piston Thrust	Number of Wheels Coupled	Length of Crank.	Diam. of Journal.	Centre of Connecting Rod to Centre of Journal.	Load on Journal.	Centre of Journal to Centre of Rail.	Bending Stress due to Piston Thrust. A.	Bending Stress due to Load on Journal. B.	Torsional Stress. T.	Resultant of Stresses. A and B	Resultant of Stresses. A, B, & T.	Bending Stress due to Piston Thrust. A.	Bending Stress due to Load on Journal. B.	Torsional Stress. T.	Resultant of Stresses. A and B.	Resultant of Stresses. A, B, & T.
Lbs.		Ins.	Ins.	Ins.	Lbs.	Ins.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
15,360	6	13	7¼	18¼	10,640	8¼	7,380	2,350	1,320	7,760	7,980	9,150	2,915	1,630	9,600	9,870
29,900	4	12	7	17¾	11,200	7½	7,750	2,490	1,330	8,130	8,390	9,790	3,120	1,668	10,280	10,550
17,040	4	13	8	14⅛	12,320	6⅞	6,730	1,620	1,525	6,950	7,275	8,170	1,970	1,850	8,100	8,500
49,600	4	12	8½	16¾	14,500	7½	6,900	1,800	1,235	7,130	7,345	8,270	2,170	1,480	8,550	8,900
33,100	4	12	7½	15¾	12,000	7⅞	6,300	2,250	1,200	6,700	6,910	7,750	2,770	1,470	8,230	8,500
40,750	Single	14	8½	13½	14,000	6	9,140	1,395	2,340	9,250	9,810	10,960	1,670	2,800	11,080	11,810

Crank Axles.

							Stress at Centre.				
Total Piston Thrust	Length of Crank.	Diameter of Journal.	Diameter at Centre.	Centres of Cranks.	Centres of Journals.	Load on Journal..	Bending Stress due to Piston Thrust. A.	Bending Stress due to Load on Journal. B.	Torsional Stress. T.	Resultant of Stresses. A and B.	Resultant of Stresses. A, B, and T.
Lbs	Inches	Inches.	Inches.	Inches.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
35,620	12	7½	7¼	29	49	15,800	9,560	2,100	2,870	9,800	10,580
13,300	13	8¼	7¾	28½	47½	14,000	9,020	1,770	3,100	9,200	10,150
10,900	13	7½	7	28½	47½	12,000	11,120	2,030	3,960	11,300	12,550
34,050	12	7¾	7	29½	48⅝	11,500	9,690	1,770	3,050	9,850	10,725
19,600	13	8½	8	28⅓	48¼	13,000	9,750	1,395	3,220	9,860	10,830
13,000	13	8½	8	28½	48½	11,500	8,560	1,235	2,790	8,660	9,460

CRANK AXLES (*continued*).

Total Piston Thrust.	Stress on New Journals.					Stress on Journals worn ⅛ inch.				
	Bending Stress due to Piston Thrust. A.	Bending Stress due to Load on Journal.. B.	Torsional Stress. T.	Resultant of Stresses. A and B.	Resultant of Stresses. A, B, and T.	Bending Stress due to Piston Thrust. A.	Bending Stress due to Load on Journal. B.	Torsional Stress. T.	Resultant of Stresses. A and B.	Resultant of Stresses. A, B, and T.
Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
35,620	8,620	1.910	2,590	8.830	9,540	10,600	2.350	3.180	10.850	11.720
43,300	7,470	1,460	2,560	7.600	8.380	9 030	1,760	3,090	9.220	10,160
40.900	9,410	1,670	3,220	9,550	10,510	11,550	2,050	3,960	11,720	12.930
34,050	7,880	1,440	2,470	8,020	8,720	9.690	1.770	3,040	9,840	10.700
49,600	8.140	1,160	2.680	8.230	8.920	9.760	1.390	3.220	9.870	10,830
43,000	7,050	1,030	2,330	7,130	7,830	8.470	1,230	2.790	8,560	9.400

Piston Rods.

Tensile stress at centre

$$= \frac{40750}{3 \times 3 \times \cdot 7854} = 5{,}770 \text{ lbs.}$$

Stress at column

$$= \frac{40750}{3 \times 3 \times \cdot 7854}\left(1 + \frac{1 \times 49 \times 49}{2250 \times 3 \times 3}\right) = 6{,}800 \text{ lbs.}$$

Stress at bottom of thread. Diameter = 2·66″

$$= \frac{40750}{2\cdot 66 \times 2\cdot 66 \times \cdot 7854} = 7{,}330 \text{ lbs.}$$

Stress through keyway

$$= \frac{40750}{6\cdot 1} = 6{,}690 \text{ lbs.}$$

Shearing stress on key

$$= \frac{40750}{1\cdot 48 \times 2} = 13{,}760 \text{ lbs.}$$

Coupling Rods. Four-wheel Coupled Engines.

Centrifugal force

$$= \frac{166 \times (1\cdot 833 \times 3\cdot 1416 \times 5\cdot 833)^2}{32 \times \cdot 916} = 6{,}400 \text{ lbs.}$$

Tensile stress

$$= \frac{17025}{3\frac{3}{4} \times 1\frac{1}{2}} = 3{,}030 \text{ lbs.}$$

Stress as column with fixed ends, tending to buckle horizontally

$$= \frac{17025}{4\frac{1}{2} \times 1\frac{1}{2}}\left(1 + \frac{1 \times 94 \times 94}{3000 \times 1\frac{1}{2} \times 1\frac{1}{2}}\right) = 5{,}820 \text{ lbs.}$$

Stress as column with round ends tending to buckle vertically

$$= \frac{17025}{4\frac{1}{2} \times 1\frac{1}{2}}\left(1 + \frac{1 \times 94 \times 94}{750 \times 4\frac{1}{2} \times 4\frac{1}{2}}\right) = 3{,}990 \text{ lbs.}$$

Stress due to centrifugal force

$$\frac{6400 \times 94 \times 6}{8 \times 1\frac{1}{2} \times 4\frac{1}{2} \times 4\frac{1}{2}} = 14{,}850 \text{ lbs.}$$

Coupling Rods. Six-wheel Coupled Engines.

Centrifugal force, coupled end

$$= \frac{133 \times (1\cdot 833 \times 3\cdot 1416 \times 5\cdot 833)^2}{32 \times \cdot 916} = 5{,}120 \text{ lbs.}$$

Centrifugal force, solid end

$$= \frac{166 \times (1\cdot 833 \times 3\cdot 1416 \times 5\cdot 833)^2}{32 \times \cdot 916} = 6{,}400 \text{ lbs.}$$

Tensile stress

$$= \frac{11250}{3\frac{1}{4} \times 1\frac{1}{2}} = 2{,}330 \text{ lbs.}$$

Stress as column, coupled end, tending to buckle horizontally

$$= \frac{11350}{4\frac{1}{2} \times 1\frac{1}{2}} \left(1 + \frac{1 \times 76 \times 76}{3000 \times 1\frac{1}{2} \times 1\frac{1}{2}}\right) = 3{,}120 \text{ lbs.}$$

Stress as column, solid end, tending to buckle horizontally

$$= \frac{11350}{4\frac{1}{2} \times 1\frac{1}{2}} \left(1 + \frac{1 \times 94 \times 94}{3000 \times 1\frac{1}{2} \times 1\frac{1}{2}}\right) = 3{,}880 \text{ lbs.}$$

Stress due to centrifugal force, coupled end

$$= \frac{5120 \times 76 \times 6}{8 \times 1\frac{1}{2} \times 4\frac{1}{2} \times 4\frac{1}{2}} = 9{,}590 \text{ lbs.}$$

Stress due to centrifugal force, solid end

$$= \frac{6400 \times 94 \times 6}{8 \times 1\frac{1}{2} \times 4\frac{1}{2} \times 4\frac{1}{2}} = 14{,}850 \text{ lbs.}$$

Connecting Rods.

Centrifugal force

$$= \frac{138 \times (2 \times 3{\cdot}1416 \times 5{\cdot}833)^2}{32 \times 1{\cdot}916} = 3{,}020 \text{ lbs.}$$

Tensile stress

$$= \frac{34050}{3 \times 1\frac{5}{8}} = 7{,}000 \text{ lbs.}$$

Stress as column, tending to buckle horizontally

$$= \frac{34050}{3\frac{7}{8} \times 1\frac{3}{4}} \left(1 + \frac{1 \times 72 \times 72}{3000 \times 1\frac{5}{4} \times 1\frac{3}{4}}\right) = 7{,}830 \text{ lbs.}$$

Stress as column, tending to buckle vertically

$$= \frac{34050}{3\frac{7}{8} \times 1\frac{3}{4}} \left(1 + \frac{1 \times 72 \times 72}{750 \times 3\frac{7}{8} \times 3\frac{7}{8}}\right) = 7{,}350 \text{ lbs.}$$

Stress due to centrifugal force

$$= \frac{3020 \times 72 \times 6}{8 \times 1\frac{3}{4} \times 3\frac{7}{8} \times 3\frac{7}{8}} = 6{,}220 \text{ lbs.}$$

Crank Pins.

Primary bending moment, due to piston thrust

$$= 45300 \times 8'' = 362{,}400 \text{ lbs.}$$

Counter bending moment due to coupling rod

$$= \frac{45300 \times 2\frac{3}{8} \times 2}{3} = 71{,}800 \text{ lbs.}$$

Actual bending moment

$$= 362400 - 71800 = 290{,}600 \text{ lbs.}$$

Stress

$$= \frac{293600}{\cdot 0982 \times 5\frac{3}{4} \times 5\frac{3}{4} \times 5\frac{3}{4}} = 15{,}620 \text{ lbs.}$$

Slide Bars.

Load on bars

$$= \frac{34050 \times 12}{72} = 5{,}675 \text{ lbs.}$$

Stress

$$= \frac{5675 \times 45\frac{1}{2} \times 6}{4 \times 5 \times 2 \times 2} = 19{,}350 \text{ lbs.}$$

Driving Axles for Outside Cylinder Engines.

Bending stress due to piston thrust (A)

$$= \frac{45360 \times 18\frac{1}{4}}{3 \times \cdot 0982 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4}} = 7{,}380 \text{ lbs.}$$

Bending stress due to load on journal (B)

$$= \frac{10640 \times 8\frac{1}{4}}{\cdot 0982 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4}} = 2{,}350 \text{ lbs.}$$

Torsional stress (T)

$$= \frac{45360 \times 13}{3 \times 2 \times \cdot 196 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4}} = 1{,}320 \text{ lbs.}$$

Resultant of stresses A and B

$$= \sqrt{7380^2 + 2350^2} = 7{,}760 \text{ lbs.}$$

Resultant of stresses A, B, and T

$$= \frac{7760}{2} + \sqrt{\frac{7760^2}{4} + 1320^2} = 7{,}980 \text{ lbs.}$$

Crank Axles. Stress at Centre.

Bending stress due to piston thrust (A)

$$= \frac{35620 \times 24\frac{1}{2} - 35620 \times 14\frac{1}{2}}{\cdot 0982 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4}} = 9{,}560 \text{ lbs.}$$

Bending stress due to load on journal (B)

$$= \frac{15800 \times 29\frac{1}{2} - 15800 \times 24\frac{1}{2}}{\cdot 0982 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4}} = 2{,}100 \text{ lbs.}$$

Torsional stress (T)

$$= \frac{35620 \times 12}{\cdot 196 \times 7\frac{1}{4} \times 7\frac{1}{4} \times 7\frac{1}{4} \times 2} = 2{,}870 \text{ lbs.}$$

Resultant of stresses A and B

$$= \sqrt{9560^2 + 2100^2} = 9{,}800 \text{ lbs.}$$

Resultant of stresses A, B, and T

$$= \frac{9800}{2} + \sqrt{\frac{9800^2}{4} + 2870^2} = 10{,}580 \text{ lbs.}$$

Stress on New Journals.

Bending stress due to piston thrust (A)

$$= \frac{35620 \times 10}{\cdot 0982 \times 7\frac{1}{2} \times 7\frac{1}{2} \times 7\frac{1}{2}} = 8{,}620 \text{ lbs.}$$

Bending stress due to load on journal (B)

$$= \frac{15800 \times 5}{\cdot 0982 \times 7\frac{1}{2} \times 7\frac{1}{2} \times 7\frac{1}{2}} = 1{,}910 \text{ lbs.}$$

Torsional stress (T)

$$= \frac{35620 \times 12}{\cdot 196 \times 7\frac{1}{2} \times 7\frac{1}{2} \times 7\frac{1}{2} \times 2} = 2{,}590 \text{ lbs.}$$

Resultant of stresses A and B

$$= \sqrt{8620^2 + 1910^2} = 8{,}830 \text{ lbs.}$$

Resultant of stresses A, B, and T

$$= \frac{8830}{2} + \sqrt{\frac{8830^2}{4} + 2590^2} = 9{,}540 \text{ lbs.}$$

TEN MINUTES' RULE.

The President said the paper was now open to discussion and he would like to make one remark before it began. Last year his work as President was criticised in one particular, viz., that he sometimes let members speak too long. The rule of the Institution was that no one should speak more than ten minutes. The only exception might be when some one came direct from London or a long distance to speak particularly on a certain subject. There he might in that case be allowed some latitude. Any man ought to give his views well and clearly within the limit of ten minutes, if he had thought the subject over and was able to express himself properly. Having said that, he had to emphasise the fact that no one should speak more than ten minutes.

DISCUSSION.

The President said there was nothing to be afraid of in the locomotive engine. Most of them were marine engine makers. The works he belonged to were first famous for locomotives and took to marine engines afterwards. As marine pressures went higher it gave the old locomotive men a great advantage, because they were used to high pressures to begin with. Thirty years ago in the Royal Navy and elsewhere, engine boilers were working at 20 lbs. pressure, whilst locomotive engines were not far short of where it had got now, over 100 lbs. As

marine engineers adopted compound engines and the pressures went up to 60 lbs., and, so on, the marine engineering men were terribly afraid they were going into an unknown country. It was nothing for people at places like Hawthorn's to do this, they had been used to these high pressures, and that showed how the locomotive helped forward the marine engine, and being a lighter machine and constantly repeated the part could be more carefully thought out: and going back to the days of their childhood, the locomotive held a higher position than the marine engine. He remembered, in 1870, a consulting engineer coming into Mr. Marshall's office and saying something to this effect: "I have studied the marine engine up to this point, and you will see it will develop more and more in the direction of the locomotive engine." It went on in the direction of a much more elaborate boiler and much higher pressures, and they knew what pressures had been reached in the water tube boiler; also the number of revolutions had increased, and the weight per horse-power developed had very greatly diminished. In point of fact, the marine engine had gone far ahead of the locomotive engine.

Mr. J. R. FOTHERGILL rose more to congratulate the writer of the paper than to discuss its contents. Although he served his time in a locomotive shop, he was sorry to say that was so many years ago now that he was out of touch with the locomotive engine of the present day. So he scarcely dared venture to discuss the paper; but what the Institution must feel was this "breaking the record," in a sense, because that was the first locomotive paper they had had. Although it was an Institution of "Marine Engineers and Shipbuilders," many of their members were locomotive builders, and they thought these members should be associated with the literature of the Institution. The paper seemed to him to combine most valuable and interesting information. It must have taken a great deal of working out to arrive at the formulæ given. It was very desirable to have such a paper fully discussed. He personally thanked the author for giving it.

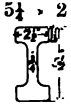
The PRESIDENT thought he should say a little on the paper on its own merits. It looked a most excellent paper—it was full of useful information. Perhaps it was a paper that was not so easy of discussion, because it was very much based on calculation, and probably, as far as they could see, the calculations all correctly worked out limited the opportunity for criticism. When he (the President) was young, when a paper of this kind came before the Institution, full of figures, it was

always the custom of the President to say he commended the study of the paper to the young members; so he commended it to their study. The locomotive engine was the most complete, self-contained machine they had got. It was the only machine that goes altogether. It had both advantages and disadvantages that did not apply to anything else. For example, a good marine engine might be tossed about in the severest storm, and only came to hopeless grief when the ship ran upon the rocks. Otherwise when at sea it must be kept going for days and perhaps weeks without difficulty. Now the locomotive went into the "doctor's shop" for twelve hours every day, and that made it live much longer than it would do otherwise. A point Mr. Jennings had not touched upon was this, they could run dimensions very fine in a locomotive boiler and fill it very full of tubes. If they did the same in a stationary boiler, the steam would hang to the under sides of the tubes and not get away freely; but when shaken up in the running locomotive it got away more freely. He had pointed out how the locomotive engine gave the marine engine a lift forward, and the locomotive itself was now probably on the verge of improvement. Railways were breaking down on the volume of their traffic. They must look to a development by which they could run much heavier trains, and in some degree (though not so much) to increasing their speed, and that might require a reconsideration of the whole of the locomotive design. As they did that they must consider more and more the strains and the stresses in the most careful and thoughtful manner for all weight put upon the locomotive had to be considered in respect to the extra weight put upon the permanent way. In some ways the manufacture of the locomotives in England was at a disadvantage, as nearly all railways made their own engines. There were some reasons for and some against the locomotives as made and worked always under the eye and charge of the locomotive superintendent. In other words, the child was brought up under the parent's eye, worked under the parent's eye, and from the cradle to the grave, never went out of its parent's hands, and he naturally gave the best records of its services and not of its weaknesses. A parent was, perhaps, a little blind to the faults of his children, and the same might apply to the locomotive superintendent. An outside criticism as to the engineering of an English railway was what one never got. Compare this with the marine engine, where people were rather inclined to go out of their way to find fault. In the shipping world if anything went wrong many owners and officials desired to find fault with the shipbuilder or engineer, for naturally, everybody was most anxious to throw the blame upon somebody

Coupling Rods. Six-wheel Coupled Engines.

Total Piston Thrust. L	Load for Tension and Column Calculations. $\frac{L}{3}$	Length Coupled End.	Length Solid Ends.	Centre of Driving Crank Pin to Centre of Coupling Pin.	Section at Ends.	Section at Centre.	Diameter of Crank Pin Path.	Weight Coupled End.	Weight Solid End.	Centrifugal Force of Coupled End at 350 Revolutions.	Centrifugal Force of Solid End at 350 Revolutions.	Tensile Stress.	Stress as Column Coupled End.	Stress as Column Solid End.	Stress due to Centrifugal Force Coupled End.	Stress due to Centrifugal Force Solid End.
Lbs.	Lbs.	Ins.	Ins.	Ins.	Ins. Ins.	Ins. Ins.	Ins.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
34,050	11.350	82	94	6	$3\frac{1}{4} \times 1\frac{1}{2}$	$4\frac{1}{2} \times 1\frac{1}{2}$	22	133	166	5.120	6,400	2.330	3,120	3.880	9,590	14.850
47,040	15.680	108	90	$6\frac{3}{4}$	$3\frac{1}{2} \times 1\frac{1}{2}$	4×2	18	188	167	5,900	5,250	2,980	3,640	3,280	13.990	11,070
40.900	13.633	99	87	6	$4\frac{1}{4} \times 1\frac{1}{2}$	$4\frac{1}{4} \times 1\frac{1}{2}$	20	167	157	5.750	5,410	2,130	4,870	4,530	14,800	13.000
43.300	14.433	99	87	6	$4\frac{1}{4} \times 1\frac{1}{2}$	$4\frac{1}{4} \times 1\frac{1}{2}$	22	167	157	6,440	6,050	2,260	5,160	4.770	16,600	14,550
38,170	12.723	93	93	$7\frac{1}{2}$	$4\frac{5}{8} \times 1\frac{1}{2}$	$4\frac{5}{8} \times 1\frac{1}{2}$	22	168	182	6,480	7,020	1,835	3,820	4.180	12,950	15,200
43,000	14.333	108	93	$6\frac{3}{4}$	$3\frac{3}{4} \times 1\frac{7}{8}$	$4\frac{1}{4} \times 1\frac{7}{8}$	20	215	197	7,550	6,920	2,040	3,560	3,280	16,950	14,230

Connecting Rods.

Total Load.	Stroke.	Length.	Section, Small End.	Section, Large End.	Radius for Centrifugal Force Formula.	Total Weight of Rod minus Ends.	Centrifugal Force at 350 Revolutions per Minute.	Tensile Stress.	Stress as Column Horizontally.	Stress as Column Vertically.	Stress due to Centrifugal Force.
Lbs.	Inches.	Inches.	Ins. Ins.	Ins. Ins.	Inches.	Lbs.	Lbs	Lbs.	Lbs.	Lbs.	Lbs.
34.050	24	72	$3 \times 1\frac{5}{8}$	$4\frac{3}{4} \times 1\frac{7}{8}$	23	138	3,020	7,000	7.830	7.350	6,220
47.040	26	78	$3\frac{1}{2} \times 2$	5×2	25	187	4.420	6,720	8,350	8.040	7,150
40.750	28	83	$3\frac{3}{4} \times 1\frac{11}{16}$	$5\frac{1}{2} \times 1\frac{7}{8}$	27	193	4.800	6,450	8,550	7.090	7.840
38,170	26	$73\frac{1}{2}$	$3\frac{1}{4} \times 2$	5×2	25	171	4.040	5,870	6.700	6,580	6,550
49,600	26	85	$3\frac{3}{4} \times 2$	$5\frac{1}{4} \times 2$	25	216	5,110	6,620	8.830	8,150	8,040
49,600	24	120			23	290	6,370	6,960	13,100	10,200	10,800

Crank Pins for Outside Cylinder Engines.

Total Piston Thrust.	No. of Wheels Coupled.	Diameter of Crank Pin.	Centre of Connecting Rod Journal to Wheel Face.	Centre of Coupling Rod Journal to Wheel Face.	Primary Bending Moment due to Piston Thrust.	Counter Bending Moment due to Coupling Rod.	Actual Bending Moment.	Stress.
Lbs.		Inches.	Inches.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.
45,300	6	$5\frac{3}{4}$	8	$2\frac{3}{8}$	362.400	71,800	290.600	15,620
32.200	6	5	$7\frac{3}{4}$	$2\frac{3}{4}$	249.700	59,030	190,670	15.530
49,600	4	6	$5\frac{1}{2}$	$1\frac{1}{2}$	272.000	37,150	234,850	11.080
33,100	4	$4\frac{1}{2}$	$4\frac{3}{4}$	$1\frac{3}{8}$	157,200	22.750	134,450	15,050
47,040	4	$5\frac{1}{2}$	—	$6\frac{7}{8}$	—	161,500	161.500	9.900
35,610	4	5	—	$7\frac{3}{4}$	—	138,000	138,000	11,250

Slide Bars.

Total Piston Thrust.	Length of Connecting Rod.	Length of Crank.	Number of Bars per Cylinder.	Load on Bars.	Centres of Bolts.	Width.	Depth.	Stress.
Lbs.	Inches.	Inches.		Lbs.	Inches.	Inches.	Inches.	Lbs.
34.050	72	12	4	5,675	$45\frac{1}{2}$	$2\frac{1}{2}$	2	19,350
40,900	69	13	4	7.720	$48\frac{3}{4}$	3	$2\frac{1}{4}$	18,600
38.170	$73\frac{1}{2}$	13	4	6.750	$37\frac{3}{8}$	$2\frac{1}{4}$	$2\frac{1}{8}$	18.650
40,750	83	14	2	6,870	$49\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{5}{8}$	14,100
45,300	$101\frac{3}{4}$	13	1	5,800	49	6	$2\frac{3}{4}$	9,400
40,320	$108\frac{1}{2}$	13	1	4,830	49	6	$2\frac{5}{8}$	8,600

over mild steel. It appeared to him rather strange that they should cling to a material inferior both in elongation and tensile strength, and besides not so readily obtained in large quantities. On talking over with some friends the small bearing surfaces allowed in locomotives, he meant on the crossheads, crank pins, slide bars, etc., they came to the conclusion that the smaller bearing surface that could be used successfully in the locomotive as compared with the marine engine was due to the incessant jolting of the former causing a more perfect and rapid distribution of oil on the working parts. But no similar explanation was known to him for the very high stresses given in the paper. It would surprise most marine engineers to see that in the case of the coupling rods a factor of safety of 3 was all that was allowed. Perhaps a comparison between the histories of locomotive and of marine engines might give them a little light on the matter. The development of the locomotive since its first success had been along the line of slow and step-by-step improvement. No great changes had suddenly taken place, but steam pressures, powers, and weights had gradually risen to their present state. The improvements had been in the direction of strengthening weak points, and lightening where weight was found unnecessary, a work more due to the practical engineer than to the scientific experimenter and investigator. In marine work, on the other hand, they had changed by large steps from simple to compound, and compound to triple and quadruple expansion, while steam pressures had risen from 10 lbs. to 300 lbs. per square inch. Thus perhaps more attention may have been given to the mechanical details of the former than of the latter. He regretted that he had not been able to compile the comparative tables he had intended to bring forward. He tendered his thanks to Mr. Jennings for his valuable paper, and as a member of the Graduate Committee it was gratifying to him that another of the members of that section had been found worthy to read a paper before the senior section.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899–1900.

PROCEEDINGS.

SECOND GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUNDERLAND LITERARY SOCIETY, SUNDERLAND, ON THURSDAY EVENING, DECEMBER 14TH, 1899.

GEORGE DOBIE WEIR, ESQ., IN THE CHAIR.

Owing to the absence of the President (Sir Benjamin C. Browne), and no member of the Council being present, the meeting appointed Mr. George Dobie Weir to take the chair.

The CHAIRMAN said those present, like himself, would very much regret that the snow and severe weather had probably detained a great number of their members from coming to the meeting. He was sorry to have to report that their esteemed President was unable to be present on account of a severe cold; and their worthy Secretary, as some of them might be aware, happened a very unfortunate accident about four weeks ago, and had been confined to his bed ever since. His son (Mr. Louis Duckitt), however, would act as Secretary *pro tem.*, and he would now call upon him to read the minutes of their last General Meeting.

The minutes of the last General Meeting, held in Newcastle-upon-Tyne, on November 3rd, 1899, were read, approved by the members present, and signed by the Chairman.

The ballot for new members having been taken, the Chairman appointed Mr. W. Dalrymple, jun., and Mr. W. Stevenson to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Bennett, Percy M., Electrical Engineer, 2, Henley Street, Heaton, Newcastle-upon-Tyne.

Chambers, John, E. Draughtsman, 114, Sidney Grove, Newcastle-upon-Tyne.

Chilton, Joseph, E. Draughtsman, 47, Mary Street, Blaydon-on-Tyne.

Hardy, Henry Thomas, Ship Draughtsman, 10, The Retreat, Sunderland.

Hetherington, William, Shipbuilder, 27, Co-operative Street, Sunderland.

McGregor, Duncan, Shipwright, 5, Bishopton Street, Sunderland.

Moncrieff, John M., Civil Engineer, 2, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Purvis, Andrew Alex., Engineer 3, Victoria Avenue, Whitley Bay, Northumberland.

Reid, William, Engineer, c/o Messrs. Wm. Reid & Co., 112, Fenchurch Street, London, E.C.

Thyne, John Sinclair, Ship Draughtsman, 17, Boughton Street, Sunderland.

Whitfield, Ernest, Engineer, 11, Victoria Terrace, Low Fell, Gateshead-on-Tyne.

GRADUATES TO MEMBERS.

Bellby, Norman Harry, Marine Engineer, 1, Kingsley Place, Newcastle-upon-Tyne.

Binns, Aubrey B., Engineer, 23, Thornhill Terrace, Sunderland.

Bulmer, Septimus, Engineer, 49, Brighton Grove, Newcastle-upon-Tyne.

Carverhill, E. A., Electrical Engineer, 19, Crown Street, Newcastle-upon-Tyne.

Fox, Carter, E. Draughtsman, 7, Coxon Street, Sunderland.

Parr, Joseph E., Ship Draughtsman, 21, Zion Terrace, Newcastle Road, Sunderland.

Pierce, Robert Cecil, Electrical Engineer, 4, Simonside Terrace, Heaton, Newcastle-upon-Tyne.

Todd, George William, Ship Draughtsman, 126, Bede Burn Road, Jarrow-on-Tyne.

Wilson, John Reginald, Electrical Engineer, Lyndhurst, Gosforth, Newcastle-upon-Tyne.

ASSOCIATES.

Parker, George, Accountant, 47, John Street, Sunderland.

Towers, Michael P., Average Adjuster, Clementhorpe, North Shields.

Weller, William, Shipowner, 17, Lovaine Terrace, North Shields.

GRADUATES.

Allen, John C., Apprentice Engineer, 14, North Terrace, Newcastle-upon-Tyne.

Dixon, John Thomas, E. Draughtsman, 27, Meldon Terrace, Heaton, Newcastle-upon-Tyne.

Heck, John S., Engineer, 10, Bristol Terrace, Newcastle-upon-Tyne.

Hedley, Ralph, E. Draughtsman, 19, Belle Grove Terrace, Newcastle-upon-Tyne.

Lee, Hugh Warren, Engineer, 88, Manor House Road, Jesmond, Newcastle-upon-Tyne.

Mathews, Gordon D., Apprentice Engineer, 39, Woodbine Terrace, Pallion, Sunderland.

Potts, Herbert Joseph, E. Draughtsman, 42, Grosvenor Place, Jesmond, Newcastle-upon-Tyne.

Thew, Charlton, Engineer, [illegible], St. George's Terrace, Newcastle-upon-Tyne.

[illegible] Working [illegible] was [illegible] posed.

[illegible] paper on [illegible] Screw Pails.

ADJOURNED DISCUSSION ON MR. F. W. JENNINGS'S PAPER ON "THE WORKING STRESS OF MATERIALS USED IN BRITISH LOCOMOTIVE CONSTRUCTION."

Mr. GEORGE M. BROWN said their thanks were due to Mr. Jennings for a most interesting and valuable paper, after reading which he thought they would be compelled to admit that the accurate calculation of the actual working stresses in many of the parts of a steam engine was a very difficult matter.

He would like to point out the very high values of the stresses Mr. Jennings had obtained in some cases, *e.g.*, in the coupling rod of a four-wheel coupled engine making 350 revolutions per minute, the stress due to centrifugal force alone was over 18,000 lbs. per square inch. For the purpose of calculating stresses in coupling and connecting rods a standard speed of 350 revolutions per minute had been taken. Was this justifiable. Would it not have been better to take the maximum number of revolutions each engine was likely to make under actual working conditions, and not an arbitrary number which might either be greater or smaller than the proper number? This was an important matter, for if the assumed number of revolutious was too high, the values obtained for the stresses due to centrifugal force would also be too high. The stresses Mr. Jennings obtained were very much higher than they were accustomed to in the designing of marine engines, and some information as to the life of rods subjected to these high stresses would be most interesting.

There was one thing he could not help regretting about Mr. Jennings's paper. He had worked out the stresses due to different causes separately, and in the case of coupling and connecting rods had apparently made no attempt to find the resultant stress, which he (Mr. Brown) thought a most important matter. For instance, looking at the second example given in the table for coupling rods of four-wheel coupled engines, they found the rods subjected to a stress of 18,380 lbs. per square inch due to the centrifugal force alone Then to that he supposed they had to add to the 2,560 lbs. per square inch due to direct tension or compression. But even if they did add to the stress due to centrifugal force that due to direct tension or compression they would not get the true stress for this reason. (See Fig. 1, Plate I.)

The coupling rod was bent by the transverse force required to give it its proper acceleration, and it was also bent by the action of the longitudinal force which it transmitted from one wheel to the other. It evidently would not do to find the stress produced by the bending due to centrifugal force only, for by so doing they neglected the bending due to the longitudinal force.

In the case of a rod of uniform sectional area, let

$2l$ = Length of rod,
r = Length of crank,
ω = Angular velocity of crank,
m = Mass of unit length of the rod.
y = Deflection at a distance x from the middle point of the rod.

Then the total bending moment at any part of the rod (Fig. 1, Plate I.).

$$= \mathrm{L}y + \frac{1}{2} m\omega^2 r(l^2 - x^2) = -\mathrm{EI}\frac{d^2y}{dx^2},$$

E being the modulus of elasticity and I the moment of inertia of the section. The solution of this equation was easily obtained, and from it they found that

$$\mathrm{M} = \frac{\mathrm{EI}}{\mathrm{L}} m\omega^2 r\left[\sec\sqrt{\frac{\mathrm{L}}{\mathrm{EI}}}\cdot l \cos\sqrt{\frac{\mathrm{L}}{\mathrm{EI}}}\cdot x - 1\right].$$

If the depth of the rod were h and its sectional area A, the maximum stress would be

$$\frac{h\mathrm{M}}{2\mathrm{I}} + \frac{\mathrm{L}}{\mathrm{A}},$$

the part of it due to bending alone being $\frac{h\mathrm{M}}{2\mathrm{I}}$. This result differed slightly from that given by Mr. Jennings. In fact, if in the expression for M, L was made very small they got results identical with those of Mr. Jennings. Taking the second example of the coupling rods for four-wheeled coupled engines, and assuming L, the longitudinal load on the rod to be 23,520 lbs., he (Mr. Brown) found that the stress due to bending alone, viz., $\frac{h\mathrm{M}}{2\mathrm{I}}$ was 19,470 lbs. per square inch instead of 18,390, the increase of 1,090 lbs. being due to the action of the longitudinal load.

When the rods were not of uniform section it was no longer possible to obtain simple expressions for the bending moment and stress at any point of the rod. Even if such expressions were obtained they would most probably be too complicated for practical use. In cases of this sort an approximate solution of the question could be obtained by

graphical methods. The method given by Mr. Jennings was approximate, and could only be applied to rods of uniform section.

In view of recent events, the next question discussed by Mr. Jennings was most interesting, especially to those engaged in marine work. The question was this: Where and what was the maximum stress in the connecting rod of a high speed engine? He could not accept the method adopted by Mr. Jennings, who seemed to assume that each element of the rod described the same path as the middle one. Moreover, although none of the rods mentioned were of uniform section, Mr. Jennings took the load due to centrifugal force as being uniformly distributed along the rod. It seemed to him that each element of the rod moved with a different acceleration. If r, l, θ, ϕ were the lengths of the crank and connecting rod and the angles they made with the centre line of the engine, they had the well-known formulæ for the acceleration of the piston and the angular acceleration of the connecting rod:—

$$\ddot{y} = -r\omega^2\left[\cos\theta + \frac{n^2\cos 2\theta + \sin^4\theta}{(n^2 - \sin^2\theta)^{\frac{3}{2}}}\right]$$

$$\ddot{\phi} = -\omega^2\frac{(n^2-1)\sin\theta}{(n^2-\sin^2\theta)^{\frac{3}{2}}},$$

where ω = angular velocity of crank and $\frac{l}{r} = n$ (Fig. 2, Plate I.).

Thus at a distance x from the gudgeon the element of the rod had an acceleration

$$x\ddot{\phi} + \ddot{y}\sin\phi$$

normal to the rod, and

$$-\ddot{y}\cos\phi - x\dot{\phi}^2$$

along the rod. If m was the mass of unit length of the rod at the distance x from the gudgeon, the intensity of the transverse load there was $m\,(x\ddot{\phi} + \ddot{y}\sin\phi)$, and by calculating the value of this expression at different points of the rod a load curve could be drawn, from which, by well-known graphic methods they might deduce the curve of bending moment M, due to transverse forces alone. From this a curve could be constructed to show the value of $\frac{M}{EI}$ at every point of the rod. By treating this in the same manner as they treated the curve of transverse load they would obtain a curve showing the deflection produced by the transverse load alone. In the cases generally dealt with the deflection (y) at any point would be small. From the curve showing y another showing the value of the bending moment due to the axial load (F). Then the total bending moment at any point would be

$$M + Fy$$

approximately, for in finding y they had neglected the effect of the axial load F. In general this first approximation would, he thought, be sufficiently accurate. Then, if they drew curves showing the values of

$$\frac{h}{2I}(M + Fy),$$

the stress due to bending and of $\frac{F}{A}$, the stress due to direct tension or compression and added the ordinates they would obtain a new curve giving the maximum stress at all sections of the rod. It was evident that the result of this process would differ from that employed by Mr. Jennings. The same method could, of course, be used in the case of coupling rods which were not of uniform section. Owing to the longitudinal acceleration F was not constant along the axis of the rod, but by slightly modifying the above method that could also be taken into account.

He did not agree with Mr. Jennings that the stresses on the crank pins of inside cylinder engines were infinitesimal. In the simple case shown in the sketch the twisting moment on the body of the shaft was $\frac{1}{2}$ Pr, P being the pressure on each crank, r the length of the cranks, 2r the radius of the wheels, $\frac{a}{2}$ the centres of the cylinders, and a the distance between centres of bearings (Fig. 3, Plate I.). But the twisting moment on each pin was also $\frac{1}{2}$ Pr. He thought that the stresses in the pins would be just as severe, if not more so, than those occurring in the body of the shaft.

The CHAIRMAN, closing the discussion, said the formulæ and the graphic method Mr. Brown gave for arriving at the strength of connecting rods, came at a very opportune time. They would remember some few weeks ago there was considerable discussion in the engineering papers relative to the breaking of a connecting rod in one of the torpedo destroyers, where several men were killed. When they got the formulæ printed in the *Transactions* it would be interesting to their younger members especially to find the strains set up in the connecting rod that broke by the methods indicated in Mr. Brown's remarks.

Mr. W. J. Jennings's reply was deferred till the next meeting.

SCREW FANS.

By CHARLES H. INNES, M.A.

[Read before the Institution, in Sunderland, on December 14th, 1899.]

It is a well-known fact that the mechanical efficiency of centrifugal fans is generally higher than that of screw or axial flow fans, but where space is limited, and a large volume of air is required at a low pressure, the latter are preferred to the former in spite of this defect. In most screw fans known to the author designed in this country, the fan is a modification of a propeller, having three or more blades, and working in a circular space through which the air passes. In his paper on "Centrifugal Fans," the writer showed that the twisting moment on the shaft in foot-pounds is equal to the change of the moment of momentum of the air passing through the fan per second. If, then, the air approaches the fan in an axial direction, as is usually the case, there is no moment of momentum, and if any work is done by the shaft the air must leave with some tangential velocity in order to produce moment of momentum. If the air, after leaving the fan, continues to flow in a passage parallel to its axis, all this tangential velocity will mean so much kinetic energy, and therefore work thrown away, and the efficiency of the fan will be lower than it would be if this were saved. The writer has seen a fan in which the blades at discharge would touch a plane passing through the axis, and which corresponded to what are called Rankine vanes in a centrifugal fan, so that the tangential velocity of the air at any point on discharge from the fan was equal to the velocity of that point of the vane from which it was discharged, a manifest absurdity. It appears to the writer that there are only two methods of obtaining a reasonable efficiency, and also the necessary change of the moment of the momentum of the air. The first is by using guide vanes similar to those of a turbine, which give moment of momentum in the direction opposite to that of rotation, so that change of moment of momentum is obtained by reducing it to zero, and discharging the air axially from the fan with only so much velocity as is required to carry it through the passages it has to ventilate, which loss of energy is, of course, unavoidable. The second method is to use

a spiral discharge chamber or volute, having a suitable section similar to that of a centrifugal fan, and in this the velocity of the air may be reduced to a suitable amount. The first method may be modified by the use of a spiral chamber, through which the air flows to the fan. These methods are adopted in the screw fans designed by Prof. Rateau, of the École des Mines, St. Etienne. Fig. 1 (Plate II.) shows the wheel whose vanes are formed of steel plate fixed to the rim of a slightly conical wheel of cast iron or bronze, by means of angle irons, or by embedding them into the rim.

A radial section of the rim of one of these wheels is shown in the upper view Fig. 2 (Plate II.), and a developed cylindrical section through the centre of the vanes in the lower. In this latter view A is the wheel, and the direction of motion is upwards. The air enters from the right, passes through the guide passages *mm*, and is given therein a motion which is partially axial, and partially opposite to the direction of rotation. The vanes of the wheel then receive it without suddenly changing its direction, the angle at *a* being calculated by the parallelogram of velocities with this object, and at *b*, the point of discharge, the angle is so designed that the discharge is wholly axial. The chamber D has its inner side slightly conical in order to reduce the velocity of the air by increasing the section of discharge. A general view of one of these fans, seen from the guide passage end, is shown in Fig. 3 (Plate II.).

The alternative method is shown in Figs. 4 and 5 (Plate II.) in elevation and plan; the spiral admission chamber gives the entering air velocity in the direction opposite to that of rotation, and after leaving the fan with velocity, wholly axial, the air is discharged through a passage whose section is increased by making its inner surface the frustrum of a cone. The third method is shown in Fig. 6 (Plate II.) and needs little explanation: here the air enters parallel to the axis, and the vanes are inclined so as to receive it without shock. The change of the moment of the momentum is effected by giving the air forward tangential motion at discharge, and a volute is provided to reduce this and convert its kinetic into pressure energy.

A modification of the third method is shown in Fig. 7 (Plate II.). Here the air enters from the left, there are no guide vanes so that the air must be discharged in a forward direction from the fan. It then enters a diffuser whose inner surface is cylindric, but whose outer is a frustrum of a cone, and these two are connected by vanes which change the forward motion of the air to an axial direction, so that the greater part of its

kinetic energy is converted to pressure. A test of a ventilator of this type is given in Table I. Fans of this type are largely used on the Continent for the ventilation of buildings, theatres, ships, tunnels, etc.

TABLE I.—TEST OF AN AXIAL FAN. (EXTREME DIAMETER OF VANES 4·69 FEET.)

Number of revolutions per minute	526	545	535	532	552	556	556	564	573
Water gauge in inches ...	1·84	1·61	1·53	1·53	1·53	1·53	1·34	1·29	1·22
Kilowatts of motor... ...	10·7	9·9	9·65	9·85	10·1	10·0	9·5	9·6	9·9
Discharge in cubic feet per second	0	137	215	296	386	396	452	474	554
Foot-pounds of work by fan per second	0	1,156	1,705	2,390	3,030	3,170	3,180	3,180	3,461
Mechanical efficiency of fan and motor	0	·16	·24	·32	·41	·43	·45	·45	·47
Manometric power	·26	·21	·205	·21	·19	·19	·18	·155	·14
Volumetric power	0	·185	·30	·42	·52	·53	·61	·62	·71

DISCUSSION.

Mr. F. W. JENNINGS said when he first saw the announcement in the circular that Mr. Innes was to read a paper on "Screw Fans" he thought they were going to receive a valuable addition to their knowledge of propeller fans. He was somewhat disappointed when he saw that this type of fan was scarcely mentioned, and that he dealt solely with types of fans very little used in this country. If, however, he could find time to make a comparison between them, it would, he was sure, prove valuable to the members of the Institution. He would more particularly suggest a few particulars of the well-known Blackman fan. If he could obtain information as to their efficiency they would be able to make a very good comparison. At the end of his paper Mr. Innes gave the results of some tests of an axial fan, but they had no information as to the conditions under which these tests were made. Were they made in a laboratory with a specially constructed fan and motor, or were they made under ordinary working conditions? In any case the mechanical efficiency was very high, certainly much superior to any results obtained from propeller fans of the ordinary type. He had not calculated it, but he presumed that in this mechanical efficiency the friction of the motor was included. It would be interesting to have the efficiency with

this eliminated, that was simply $\frac{\text{horse-power in air discharged}}{\text{brake horse-power}}$. He would be much obliged to Mr. Innes if he would inform him how the amount of work done by the fan was calculated, also how the manometric power was obtained. They were unfortunately not all so well versed in the theory of fans as he was, and this would, he was sure, be of assistance to many of them. He thought it would be an advantage if the volumetric efficiency was given in the table. In the case of ventilating fans used for exhausting comparatively large quantities of air from a building, the volumetric efficiency was as important as the mechanical efficiency, and more important than the manometric power. Most of this type of fan had a free discharge when the volumetric efficiency was at a maximum. He must thank Mr. Innes for his paper. He had put a lot of valuable information in a very compact form.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

THIRD GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, JANUARY 19TH, 1900.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Sunderland, on December 14th, 1899, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Mr. R. H. Muir and Mr. J. C. Stirzaker to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Allan, John, Ship Surveyor, c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Dressler, Gustav, Engineer, Angelburger Strasse 54, Flensburg, Bremen.

Farminer, A. E., Surveyor, c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne.

Harbottle, Thomas, Marine Engineer, 5, Alexandra Terrace, Newcastle-upon-Tyne.

Jubb, Arthur, Engineer Draughtsman, 29, Coldwell Terrace, Felling-on-Tyne.

Wawn, Tom Noel, Surveyor, c/o Messrs. Lloyd's Register of Shipping, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne.

GRADUATE TO MEMBER.

Pescod, Joseph Hind, Ship Draughtsman, 1, Railway Street, Jarrow-on-Tyne.

GRADUATES.

Nelson, George, Engineer Draughtsman, 63, Stratford Road, Heaton, Newcastle-upon-Tyne.

Scott, George, Engineer Draughtsman, 36, Bede Burn Road, Jarrow-on-Tyne.

ABANDONMENT OF THE ANNUAL DINNER.

The PRESIDENT announced that after careful consideration the Dinner Committee recommended, and the Council accepted the view, that it would be well this year, owing to the trouble and war in South Africa, to postpone the Institution Dinner. Of course, as they were aware, a very great number of festive gatherings were being postponed on account of its being more in unison with the general feeling of the community. This was the decision of the Council, and he hoped it met with their approval.

FIFTEENTH SESSION AWARDS.

The PRESIDENT announced that the Engineering Medal of the Institution for the last session had been awarded to Mr. Tom Westgarth for his paper on "Works' Organisation." Mr. Westgarth wrote to the Secretary stating that urgent business engagements would probably make it impossible for him to be at the meeting and receive the award of the Council. He was not sure whether the medal came from the Council or the members of the Institution, but whoever were the donors he wished to express to them his appreciation of the honour done to him.

GRADUATES' AWARDS.

The following awards in the Graduates' Section were intimated :—
The sum of £4 to Mr. F. W. G. Snook for his paper on "Lubrication."
The sum of £3 11s. to Mr. Talbot Duckitt for his paper on "The Design and Equipment of Electrical Power Plant for Collieries."

The above amounts have to be spent on books, instruments, or articles which may be of service to the recipients.

Mr. F. W. JENNINGS replied to the discussion on his paper on "The Working Stress of Materials used in British Locomotive Construction."

The adjourned discussion on Mr. C. H. Innes's paper on "Screw Fans" was resumed and closed.

Prof. R. L. WEIGHTON read a paper on "Receiver Drop in Multiple Expansion Engines."

MR. F. W. JENNINGS'S REPLY TO THE DISCUSSION ON HIS PAPER ON "THE WORKING STRESS OF MATERIALS USED IN BRITISH LOCOMOTIVE CONSTRUCTION."

Mr. F. W. JENNINGS, in replying to the discussion on his paper, said he must thank the President for his favourable remarks on the paper. He had pointed out that whilst at one time the locomotive was held up as an example to marine engineers, it had now been left considerably behind. He (Mr. Jennings) could only hope that locomotive engineers would bestir themselves, and try to reduce this gap. The President also spoke of the difference in efficiency of a locomotive boiler when running and stationary. He (Mr. Jennings) might say that when fixed for stationary work the average locomotive boiler would burn from 25 lbs. to 30 lbs of coal per square foot of grate per hour, whilst when running it would burn from 60 lbs. to 100 lbs. The President stated that the locomotive was now probably on the verge of improvement owing to the greatly increased traffic. He (Mr. Jennings) was of opinion that the limit in size of the ordinary inside cylinder engine had now been reached, and that for the next development they would have to look to the outside cylinder engine. A careful study of American design would, he thought, repay any British locomotive engineer at the present time.

Mr. Fothergill spoke of the Institution as being composed of marine engineers and shipbuilders. The word "marine" did not appear in the official title of the Institution, and he (Mr. Jennings) was afraid that many of the electrical, not to speak of the locomotive engineering members would object to this. He sincerely thanked Mr. Fothergill for the flattering manner in which he had spoken of his paper.

As requested by Mr. A. E. Doxford, he had obtained the following information *re* the chemical analysis of the steel used in locomotive work. The North Eastern Railway Company specify for crucible steel piston rods and motion bars, and for Siemens steel forgings such as connecting rods, coupling rods, etc., that the analysis must show not more than ·1 per cent. silicon and ·05 per cent. phosphorus and sulphur. For engine and tender straight axles, not more than ·2 per cent. silicon and ·05 per cent. phosphorus and sulphur. For crank axles, not more than ·15 per cent. silicon, ·05 per cent. phosphorus and sulphur, and not less than ·3 per cent. carbon. For tyres, not more than ·2 per cent. silicon and ·05 per cent. phosphorus and sulphur; carbon to be not less than ·5 per cent.

The chemical analysis specified for the work done under Sir A. M. Rendel's supervision was as follows :—For all steel forgings, including axles, connecting rods, etc. : Carbon, ·25 per cent. to ·32 per cent., and not more than ·035 per cent. phosphorus, 1·0 per cent. manganese, and ·2 per cent. silicon. For tyres : Carbon, ·55 per cent. to ·65 per cent., and not more than ·035 per cent. phosphorus, 1·0 per cent. manganese, and ·35 per cent. silicon. For springs : Carbon, ·45 per cent. to ·8 per cent., and not more than ·035 per cent. each of phosphorus and sulphur, ·8 per cent. manganese and ·12 per cent. silicon.

Messrs. John Brown & Co. recommend the following for piston rods, slide bars, and crossheads :—Carbon, ·33 to ·38 per cent. ; silicon, ·08 to ·20 per cent. ; sulphur and phosphorus not to exceed ·03 per cent. ; manganese, ·4 to ·6 per cent. For crank axles, the carbon should be rather lower. He must thank the firms mentioned for giving him this information, which he trusted would be what Mr. Doxford required.

In reply to Mr. Griffiths, he might say that a test piece 2 inches long of one-half square inch sectional area (*i.e.*, ·798 inches diameter) might almost be looked upon as the standard for steel used in locomotive work, both in England and America. The North Eastern Railway was one of the exceptions, their test pieces being 4 inches long. With regard to American practice, he thought that, on the whole, the materials used were slightly inferior to those used in British work, and the stresses allowed a little lower.

The following were the stresses recommended by Mr. F. J. Cole in a series of articles on American locomotive design, which appeared originally in the *American Engineer* and afterwards in the *Mechanical World* :—

Piston Rods.—These are made of steel, having a tensile strength of from 75,000 lbs. to 80,000 lbs., or of iron with a tensile strength of about 52,000 lbs. The stress through keyway or at bottom of thread should not exceed 9,000 lbs. per square inch for steel, or 8,000 lbs. for iron rods. For the shearing stress on key, from 15,000 lbs. to 17,000 lbs. is recommended, the steel having a tensile strength of from 75,000 lbs. to 85,000 lbs., with an elongation of from 18 to 20 per cent.

Coupling or Parallel Rods.—These are generally made of steel, having a tensile strength of from 70,000 lbs. to 80,000 lbs., the I section being almost universal in modern engines. The following are the stresses recommended :—Tensile stress, 5,000 lbs. steel, 4,000 lbs. iron ; stress due to centrifugal force, 11,000 lbs. steel, 9,000 lbs. iron ; factor of safety for buckling to be at least 5.

Connecting or Main Rods.—Material used is similar to that for coupling rods, the I section being practically universal. Tensile stresses of 8,000 lbs. for steel and 7,000 lbs. for iron may be allowed. Factor of safety for buckling to be about 3.

Crank Pins.—These are made of steel, having a tensile strength of about 80,000 lbs., with elongation from 18 to 20 per cent. on 2 inches, the phosphorus not exceeding ·05 per cent., or of iron having a tensile strength of about 50,000 lbs. The stress for steel should not exceed 14,000 lbs. and for iron 12,000 lbs.

Slide Bars or Guides.—Mr. Cole does not deal with these in his articles, but on examination of a large number of plates of American locomotives, he found that the majority are of steel or wrought iron, the stresses being about the same as in English practice. A much larger proportion of cast iron bars are used than in this country.

Driving Axles.—These are made of either hammered iron or steel, the latter assumed to be first-class open-hearth steel of not less than 80,000 lbs. tensile stress, with elongation of not less than 18 per cent. on 2 inches. Phosphorus not to be above ·05 per cent. The following are the stresses recommended :—

	Hammered Iron.	Steel.
8 Wheel coupled	7,500 lbs. ...	8,500 lbs.
6 „	8,500 „ ...	9,500 „
4 „	10,500 „ ...	13,000 „

Crank axles are never used in America, the whole of the engines having outside cylinders.

He was sorry that Mr. Nichol had not had time to make his comparison between marine and locomotive practice more complete. He was afraid, however, that it was almost impossible to make a fair comparison between mercantile marine engine practice and locomotive, owing to the conditions of working being so entirely different; but, as pointed out by the President, a very fair comparison might be made between torpedo-boat destroyer work and locomotive. With regard to the use of Yorkshire iron instead of steel, he believed this was chiefly chosen on account of its greater ductility, rendering it suitable for parts subject to severe shocks. Another reason was, that it was more easily worked. Several of the smaller works had not facilities for machining such parts as connecting and coupling rods in one piece, consequently the ends were machined separately, and afterwards welded to the centre. Mr. Nichol's short comparison of the development of the locomotive and marine engine was probably quite correct; but he was afraid that the fact of the development of the former being due to

the purely practical engineer was scarcely an unmixed blessing, and, as suggested at the beginning of his paper, it would assist those engaged in locomotive designing considerably if scientific men could be induced to devote a little more attention to it. He was sorry to say that Mr. Nichol was not correct in describing him as a Graduate, as, although taking a great interest in that section and attending many of their meetings, he was not a *bona-fide* member of the section.

He must thank Mr. Brown for his exceedingly interesting and valuable remarks. He was afraid, however, that the formulæ given by him were too intricate to be much used in actual practice. When a locomotive draughtsman was given a coupling rod, connecting rod, or crank axle to design, he was generally told that it had to be out in the shops by to-morrow, or something of that description, and was not given sufficient time to go into the matter as thoroughly as he might like.

He had endeavoured to keep his paper as practical as possible, and had used formulæ which he had often used in actual practice, and which he thought were quite near enough for all practical purposes, although the stresses obtained might not be exactly theoretically correct. For the purposes of comparison he was obliged to fix some definite number of revolutions per minute when calculating the centrifugal forces, and 350 was the fairest he could think of. If he had, as suggested, taken the maximum number of revolutions each engine was likely to make, it would have made his paper somewhat confusing. It should also be borne in mind that locomotives often had to do different work to that for which they were designed. For instance, a six-wheel coupled goods engine, having comparatively small wheels, occasionally had to work passenger trains, when the 350 revolutions would probably be reached, although it would not be so when goods trains were being worked. It would be a very difficult matter to get correct resultant stresses on coupling rods, as suggested by Mr. Brown. The high stresses due to the centrifugal force were only reached for short periods, probably when going down hill, when the stresses due to the push or pull of the piston would be practically *nil*. There remained the stresses due to acceleration, but to take these into consideration would render the calculations very complicated, whilst making little difference in the final result, so that, on the whole, he thought he was quite justified in ignoring the resultants in the case of coupling rods. Although they were subject to such high stresses, coupling rods very seldom broke. In the majority of cases they were never renewed, but lasted as long as any other part of the engine.

The formulæ given by Mr. Brown for the acceleration of the piston and the angular acceleration of the connecting rod were not much used in practice. He personally did not consider them necessary. He ventured to say that if the stresses were calculated in the manner described in the paper, and the figures recommended were not exceeded the rods would be perfectly safe. In reference to the last item mentioned by Mr. Brown, viz., the crank pins for inside cylinder engines, he must apologise for the wording of the paper. He did not refer to the crank pins on the crank axle, which in locomotive works were generally known as connecting rod journals, but to the coupling rod crank pins fixed in the wheels, and he thought Mr. Brown would agree with him that the stresses on these were infinitesimal.

In conclusion, he must express his gratification at the excellent discussion which had taken place on this, the first locomotive paper read before the Institution, and trusted that it would not be long before they had another dealing with the same subject.

The PRESIDENT said it was his most pleasing duty to propose a cordial vote of thanks to Mr. Jennings for his paper. It was most instructive, most interesting, and showed a great amount of care on his part.

The vote was accorded by acclamation.

ADJOURNED DISCUSSION ON MR. C. H. INNES'S PAPER ON "SCREW FANS."

Prof. H. Louis, of the Durham College of Science, resuming (by invitation) the discussion on "Screw Fans," said it was an interesting subject to mining engineers, particularly at the present moment. He would like to remind the meeting, although Mr. Innes had not mentioned the fact, that screw fans had, within the last few years, been used in this country for mine ventilators. They had excellent examples in this district. There was an exceedingly good one at the Stella Colliery close by, and there was also one at Messrs. Cookson's Lead Works. Both of these were working in connection with the Parsons turbine motor. The good results thus got caused him to query the first statement in the paper, namely, that the mechanical efficiency of centrifugal fans was higher than of axial fans. He would like to ask Mr. Innes what proof he had of that statement. He himself had had no opportunity of testing screw fans as compared with radial fans, but he had been informed by those who had that the mechanical efficiency of the screw fan could be brought up to be as good as that of the radial fan. He was quite inclined to believe that, because the careful tests made by the North of England Institute of Mining and Mechanical Engineers had shown that there was not very much to choose between the efficiencies of the different forms of radial ventilators as such. It had been found that the difference between the fan at one colliery and at another had far more to do with the engine driving it than with the construction of the fan itself. Moreover, the Mortier diametral fan had been compared with various forms of radial fans and had been found to be about equal to these in efficiency. The particular type of screw fan which was most largely adopted in this country was not referred to in the paper before them, which dealt solely with various French designs. Unfortunately, the only table of tests given in the paper referred only to one fan, and they were told practically nothing about the conditions of the trial. It would be very interesting to know how the fan was arranged as regards the areas of intake and discharge. It had been found in the axial flow fan that the careful disposition of these areas contributed materially to the efficiency of the fan. He would like to know if special care had been devoted to that point in this particular case. Mr. Innes made a good deal of the fact of an axial flow being

obtained in these fans, so that the direction of the air current was not changed, and he put that forward as an advantage in comparison with the radial flow fan. For mining purposes that was rather a secondary matter, for it was very difficult, indeed, to arrange the axial flow fan so as to discharge without changing the direction of the air current. That could only be done by arranging the fan horizontally above the shaft mouth, which involved serious mechanical difficulties. If one had to turn the fan into its usual position and make it discharge horizontally, it would be found that other difficulties were encountered, notably as regards the action of the wind. In both types of fan it was almost impossible to avoid deflecting the air current twice at right angles in mine ventilation. He hoped Mr. Innes could give them a good deal more information than was contained in the table on page 45, of the test of the axial fan. One would like to know what type of fan it was, and how the tests were carried out. Finally, he would like to appeal to Mr. Innes to keep to the custom of using the English words "volumetric efficiency" and "mechanical efficiency" as more correct than the word "power," which was, of course, a literal translation from the French, but scarcely satisfactory in English.

Mr. INNES said, in reply to Mr. Jennings, that the test of the Rateau screw fan was made in the following manner:—The fan, which was 4·69 feet diameter, discharged into a long tube of 5·57 feet, closed at the farther end by a steel plate in which there was a square orifice whose area was varied, the discharge being calculated from the pressure in the tube and the section of the orifice, a coefficient of contraction varying between ·65 and ·70 being used, according to the section of the orifice. The formula for calculating the discharge per second in cubic metres being

$$Q = cA\sqrt{2\,gH} = cA\sqrt{\frac{2 \times 9{\cdot}81 \times h \times \text{density of water}}{1{,}000 \times \text{density of air}}},$$

where Q = cubic metres of air per second,
A = area of section in square metres,
c = the coefficient of contraction,
H = pressure of air in metres of air,
g = 9·81 in metric units,
h = water gauge in millimetres.

The work done by a fan could be calculated in ft.-lbs. per second by multiplying the cubic feet per second by the pressure per square foot given by the manometer, the formula being

$$\text{Ft.-lbs. per second} = \frac{62{\cdot}5\,hQ}{12} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where h = water gauge in inches
and Q = cubic feet per second,
and 62·5 = weight of 1 cubic feet of water.

In horse-power this would be—

$$\text{H.P.} = \frac{62{\cdot}5\,hQ}{12 \times 550} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a)$$

Another method of calculating the useful work done directly from the velocity of the air when the water gauge was very small, and when by a gradually expanding mouthpiece they could discharge the air with a very low velocity, so that but little kinetic energy was lost, was the following, which he had taken from a paper on propeller ventilating fans by Mr. W. G. Walker, M.I.M.E., read at a meeting of the Institution of Mechanical Engineers, on November 3rd, 1897, to which paper the writer referred anyone who wished to get a thorough knowledge of the subject :—

Work done per second in ft.-lbs.

$$= \frac{WV^2}{2g} = \frac{V^2Q}{64{\cdot}4} \times 1{\cdot}3304 \times \frac{B}{T} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where Q = cubic feet of air per second,
V = velocity of air direct from fan in feet per second,
B = barometer height in inches of mercury,
T = F + 461, where F = degrees Fahrenheit.

This expressed in horse-power would be—

$$\text{H.P.} = \frac{V^2QB}{T} \times {\cdot}00003756 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Strictly speaking, V^2 should stand for the difference of the squares of the velocities of the air discharged from the fan itself and at the end of the gradually expanding mouthpiece. The efficiency in the case of the Rateau fan, including the motor friction and a list of volumetric efficiencies, had been calculated, from which it would be seen that the volumetric efficiency was as high as 71 per cent. at the normal speed, and at the test in which the greatest quantity of air was discharged, and at which the section of the square orifice was greatest. It was in this case one square metre or 10·75 square feet.

Manometric power or efficiency was calculated from the formula

$$\mu = \frac{gH}{c_1^2},$$

where c_1 = peripheral speed in feet or metres per second,
H = head of air in feet or metres,
g = 32·2 for British units, or 9·81 per C.G.S. units.

It need hardly be said that both units gave the same results.

Volumetric power or efficiency is measured by the formula

$$\frac{Q}{c_1 r^2},$$

where Q = cubic feet or metres per second,
and r = external radius in feet or metres.

In the opinion of the writer this latter formula, although fairly well suitable for propeller fans, was not so for centrifugal; because it neglected the breadth of the wheel at discharge. The test of the Rateau fan was made in the workshop in the presence of an inspector of the French navy.

With one exception the writer had been unable to obtain from the makers of propeller fans any information of a character that could be introduced into his paper. The subject had been thoroughly thrashed out by Mr. Walker in the paper to which he had already referred, and the object of the writer was to describe the Rateau types and not the English. Table A (page 61) had been taken from Mr. Walker's paper. In these experiments the blades were plane, and were set at various angles to the plane of rotation. The discharge from the tube in which the fan was set was not the same at every radius from the axis, and was therefore measured at various radii, viz., $1\frac{7}{8}$, $5\frac{1}{8}$, $7\frac{7}{8}$, and $10\frac{5}{8}$. These velocities were multiplied by four annular areas, whose mean radii were the above; each of the three outer rings was equal to the breadth of the anemometer wheel. The velocity of the air in feet per minute, as ascertained at each of the four radii, was multiplied by the area of the corresponding rings in square feet, and the sum of the products gave the cubic feet discharged per minute. The mean velocity of the air was obtained by dividing the discharge in cubic feet by the section of the tube, or 3·141 square feet.

It was only fair to say that if Mr. Walker's formula were applied to the Rateau fan, its mechanical efficiency would be higher. Taking as an illustration the last experiment at maximum orifice, they found that the cubic feet per second = 554.

$$V = \frac{Q}{(5{\cdot}57)^2 \times {\cdot}7854} = 22{\cdot}7 \text{ feet per second.}$$

Then assuming a barometer of 29 inches and a temperature of 60 degs. Fahr., and using Mr. Walker's formula, the additional work in ft.-lbs. per second

$$= QV^2 \times \frac{1{\cdot}3304\ B}{64{\cdot}4\ T}$$

$$= QV^2 \times {\cdot}001151 = 327 \text{ ft.-lbs.}$$

Hence the ft.-lbs. per second = 3,788 instead of 3,461, and the efficiency would be

$$\frac{3{,}788}{3{,}461} \times 47 = 51{\cdot}2 \text{ per cent.}$$

The highest mechanical efficiency obtained by Mr. Walker was 43 per cent., with a fan having a slight curve in its blades,* and the volumetric efficiency was 89·8 at this test, and the writer was of opinion that where the pressure was negligible, guide vanes were of little service, but that their advantage was very evident, even with a small water gauge.

The following table would be of service to those making experiments with fans :—

WEIGHTS OF DRY AIR AND A SATURATED MIXTURE OF AIR AND VAPOUR AT DIFFERENT TEMPERATURES UNDER THE ORDINARY ATMOSPHERIC PRESSURE OF 29·921 INCHES OF MERCURY.

Temperature in Degrees Fahrenheit.	Weight of Cubic Foot of Air Saturated with Vapour.	Weight of a Cubic Foot of Dry Air.
	Lbs.	Lbs.
0	·0864	·0864
12	·0841	·0842
22	·0823	·0824
32	·0805	·0807
42	·0788	·0791
52	·0772	·0776
62	·0756	·0761
72	·0739	·0747
82	·0723	·0733
92	·0707	·0720
102	·0688	·0707
112	·0670	·0694
122	·0650	·0682
132	·0630	·0671
142	·0609	·0660
152	·0584	·0649
162	·0557	·0638
172	·0527	·0628

If the mean density of dry and saturated air was taken, the possible error was not more than 1½ per cent. up to 102 degs.

In reply to Mr. Louis, he (Mr. Innes) acknowledged that fairly good results were obtained with propeller fans, and many of these were no doubt quite as good as some of the centrifugal fans now in use, in whose

* Fan 8, Table I., page 458 of Mr. Walker's paper.

design scientific knowledge was entirely wanting; but Mr. Louis would find it exceedingly difficult to find a propeller fan whose mechanical efficiency would equal that of the Rateau centrifugal ventilator, which had given efficiencies of 83·9, 81·8, and 82·6 when tested at the Mines de la Loire (siège de Villars).* This fan had been designed in a thoroughly scientific manner. Many centrifugal fans were mere open running fans, which could not be any more efficient than a centrifugal pump without a volute, and which probably only continued to exist because the anemometer exaggerated the discharge. He merely wished to maintain that the efficiency of a well-designed centrifugal fan was higher than that of an ordinary propeller fan. Of course, if the engine driving the fan were neglected the fan would appear to great disadvantage. The only test of the Mortier fan with which the writer was acquainted gave an efficiency of motor and fan no higher than 50·6 per cent., which was only 3·6 per cent. above that of the Rateau screw ventilator. The object of this paper was to deal with the Rateau fan, and not those of other makers.

Mr. Louis seemed entirely to misunderstand the advantage of axial discharge. If the fan discharged the air with a whirling motion as well as an axial, more energy would be lost than would be the case if there were only the axial velocity. If, however, the chimney of the fan was given a bend, so that the air might be discharged upwards and yet the fan might have a horizontal shaft, it would still be advantageous to get rid of the whirling motion of the air, and the advantage of axial discharge would be just as great as before. A horizontal axis was preferable to a vertical, but the Rateau screw fan could be arranged with a vertical axis and driven direct by an electro motor, or by an engine with a horizontal shaft by means of bevel gearing. Mr. Louis wished to know what type of fan was referred to in the table. It was very clearly stated at the end of the paper that it was the fan illustrated in Fig. 7 (Plate II.).

Finally, he (Mr. Innes) thought that to speak of volumetric and manometric efficiencies was very misleading, as the purchaser, who may not have studied the subject, was liable to confuse them with mechanical efficiency, and the word power used by the leading authority on fans seemed a happy substitute.

* From the *Revue Universelle des Mines*, vol. xx., 1892, in a paper on "Ventilateurs des Mines," Table IV.

TABLE A.

EXPERIMENTS ON A PROPELLER VENTILATING FAN, WITH PLANE BLADES SET AT DIFFERENT ANGLES TO THE PLANE OF REVOLUTION. FAN DIAMETER, 23¾ INCHES, REVOLVING IN TUBE, 24 INCHES DIAMETER; SPEED, 600 REVOLUTIONS PER MINUTE, ANEMOMETER PLACED AT RADII OF 1⅞, 5⅛, 7⅞, 10⅝ INCHES.

Angle of Blades.	Motor.		Velocity of Air in Feet per Minute at Radius.				Cubic Feet of Air per Minute.	Horse-Power.		Efficiencies.	
	Volts.	Ampères.	1⅞	5⅛	7⅞	10⅝		Brake.	Air.	Mechanical.*	Volumetric.
15°	40	1·05	460	470	510	510	1,562	·0115	·0038	33·0	41·4
20°	45	1·22	570	590	610	630	1,916	·0181	·0070	38·5	50·8
25°	52	1·36	630	680	730	770	2,291	·0282	·0120	42·2	60·8
27°	55	1·43	640	710	790	820	2,423	·0334	·0143	42·8	64·3
30°	60	1·66	665	770	875	860	2,598	·0423	·0176	41·6	68·9
35°	67	1·87	685	830	920	875	2,705	·0538	·0199	37·0	71·7
40°	76	2·12	705	855	970	900	2,805	·0707	·0222	31·4	74·4
45°	84	2·40	780	910	960	880	2,827	·0858	·0227	26·4	76·7
50°	91	2·59	790	880	930	870	2,771	·1024	·0214	20·9	75·2
60°	86	2·48	210	290	450	680	1,534	·0911	·0035	3·8	40·7

* Mechanical efficiency calculated from the quantity in formula (3) divided by the brake horse-power.

'RESIDENT desired the meeting to accord to Mr. Innes a vote of
r his useful paper on screw fans. When they got it printed it
much easier to deal with, the tables and addenda having to be
ı the *Transactions*. He asked them to accord a hearty vote of
ı Mr. Innes by acclamation.

RECEIVER DROP IN MULTIPLE EXPANSION ENGINES.

By Professor R. L. WEIGHTON, M.A., Vice-President.

[Read before the Institution, in Newcastle-upon-Tyne, on January 19th, 1900.]

The object of this paper is to give and explain the results obtained from certain trials recently completed on the experimental engines at the College of Science, Newcastle-upon-Tyne. These trials were made with a view to determine the most economical point of steam cut-off in the larger cylinders of multiple expansion engines—that is to say, in the low-pressure cylinder of double expansion, in the intermediate and low-pressure cylinders of triple expansion, and in the two intermediate and low-pressure cylinders of quadruple expansion engines.

The importance of this question was brought into view very early in the course of the trials generally with those engines. In the last paper which the writer had the privilege of bringing before the Institution the matter was referred to as requiring elucidation.*

So far as the writer is aware, there has hitherto been no experimental determination of the point in question. During the course of engine trials having various objects in view, it very soon became evident that the point of cut-off in the larger cylinders had a considerable effect upon the results obtained, economical and otherwise. In order that this disturbing cause should be eliminated from the results, it appeared that prior to any further experiments it would be necessary to determine what *was* the best point of cut-off in each cylinder. Independent of this, however, it was also obvious that the question had in itself an important bearing upon practice, from the point of view of engine design, proportions, and working, generally. For this twofold reason the several series of trials here recorded were undertaken.

The specific object of the trials was to determine *the* receiver drop (often referred to as free or intermediate expansion) between any two cylinders, with which was associated maximum economy, and incidentally to discover, in addition, the general effects of varying amounts of receiver drop in given conditions.

* See *Transactions of the North-East Coast Institution of Engineers and Shipbuilders*, vol. xiii., page 88.

The principal results are tabulated in Tables I. to V. (pages 70 to 72), and are graphically recorded on Diagrams I. to X. (Plates III. to XII.).

Table I. (page 70) refers to results obtained from triple-expansion engines having cylinders 7 inches, 15½ inches, and 23 inches diameter. The stroke in all cases is 18 inches. From this table it will be seen that the method adopted was to change or vary only one condition at a time, viz., the cut-off, first in the intermediate-pressure and next in the low-pressure cylinder, all the other conditions being kept as nearly as possible constant and unvarying throughout the trials of a series.

During the first six trials the intermediate-pressure cut-off was varied, and during the second six the low-pressure cut-off was the condition which was varied. In Diagram I. (Plate III.) the results of Table I. are recorded. The base-line represents in inches the point of cut-off in intermediate-pressure and in low-pressure respectively. Ordinates represent, (1) Water used per hour, (2) Brake horse-power, (3) Water used per brake horse-power per hour.

The water used per hour at constant revolutions—in these tables 140 revolutions per minute are chosen throughout—lies in a straight line, marked "W" on the diagram. This line shows that the water consumption at constant revolutions increases with the cut-off in the larger cylinders, and that the rate of increase is much greater when the intermediate-pressure cut-off is made later than when the low-pressure cut-off is made later. A notable exception to this occurs when the jackets are in use, Diagram VI. (Plate VIII.), in which case the consumption is constant at all cuts-off, as would naturally be expected from the temperature-equalising effect of the jackets. The brake horse-power lies in a curve, which curve attains in most of the trials a maximum height, and then falls as the cut-off is further increased. The water per brake horse-power, being the straight line ordinates divided by the curve ordinates, lies also in a curve. The lowest point of this curve indicates the cut-off at which maximum economy of water per horse-power occurs. In Diagram I. the maximum-economy cut-off in the intermediate-pressure cylinder is about 6⅝ inches, and in the low-pressure about 10½ inches.

Table II. (page 71) and Diagram II. (Plate IV.) refer to cylinders 7 inches, 10½ inches, and 23 inches diameter, and here it will be noticed that the best cuts-off occur in the intermediate-pressure cylinder at 11 inches, and in the low-pressure at about 6⅜ inches.

Diagram III. (Plate V.) refers to cylinders 10½ inches, 15½ inches, and 23 inches diameter, and shows the best cuts-off in both inter-

mediate-pressure and low-pressure cylinders to be about 10¾ inches. In this diagram and the next one, let it be noted that the boiler pressure is 120 lbs. per square inch as against 210 lbs. in the two previous diagrams.

Diagram IV. (Plate VI.) shows results under exactly the same conditions as No. III., with the single exception that the high-pressure cut-off is 9 inches, instead of 6 inches, as in No. III. This series was made to discover what influence—if any—the total number of expansions had upon the maximum-economy cuts-off in the larger cylinders of the engines. It will be seen that the best cut-off in Diagram IV. for both cylinders is about 10¾ inches, which agrees with the result of Diagram III. The high-pressure cut-off point has therefore no apparent effect, and this is confirmed in Diagram V. (Plate VII.) for quadruples, referred to further on. Neither has the boiler pressure any effect upon the maximum-economy cut-off, as is evidenced by a comparison of the cuts-off in low-pressure and intermediate-pressure of Diagrams I. and II. respectively, with the cuts-off in intermediate-pressure and low-pressure of Diagrams III. and IV. These cuts-off, taking them in the order mentioned, are 10½ inches, 11 inches, 10¾ inches, and 10¾ inches, the cylinder ratios being in all these cases practically the same, viz., 2·195 and 2·296.

Diagram V. (Plate VII.) gives the curves of water used per brake horse-power per hour for quadruples having cylinders 7 inches, 10½ inches, 15½ inches, and 23 inches diameter, at various degrees of total expansion of the steam, ranging from that corresponding to a high-pressure cut-off of 3 inches, down to a cut-off of 12 inches.

From this diagram two conclusions may be drawn, first, that degree of total expansion does not affect materially the point of maximum-economy cut-off in the larger cylinders, thus corroborating the comparison of Nos. III. and IV., and, second, that the best points of cut-off in the larger cylinders of quadruples are governed by the same influences as in triples. The ratios of the quadruple cylinders are practically all the same, and are identical with the ratios of Diagrams III. and IV. The best cut-off is about 10½ inches on the average. This is to be compared with the best cut-off in Diagrams I., II., III., and IV. for the same cylinder ratio.

Owing to the space they would occupy, it has not been thought desirable to give tables for all the diagrams. Those corresponding to Diagrams III., IV., and V. are therefore omitted.

All the trials so far referred to were made without jacket steam. In

order to determine what influence jackets might have on the results, a series of trials were made, the results of which are given in Table III. (page 71) and Diagram VI. (Plate VIII.). The curves of this diagram are to be compared with those of Diagram II. when the low-pressure cut-off was varied.

The best cut-off in the low-pressure cylinder with steam in the jackets is about $5\frac{3}{4}$ inches, as against $6\frac{3}{8}$ inches without jacket steam. The legitimate conclusion seems to be that jackets have no material effect upon the cut-off of maximum economy.

Table IV. (page 72) and Diagram VII. (Plate IX.) show results of trials made with the intermediate-pressure receiver capacity doubled as compared with its capacity under the conditions of Diagram II. An inspection of Diagram VII. shows that the best cut-off in the intermediate-pressure cylinder is practically identical with that of Diagram II. It may therefore be concluded that variation in receiver capacity—at least within limits generally possible in practice—has no sensible effect upon the maximum-economy cut-off in the larger cylinders.

It was not thought necessary in the two last series of trials to duplicate the experiments by varying the cut-off in the other cylinder, as had been done in all the previous trials.

Table V. (page 72) and Diagram VIII. (Plate X.) give results from the engines arranged as double expansion or compound engines, with cylinders 7 inches and 23 inches diameter, corresponding to a cylinder ratio of 11. In this case maximum economy cut-off in the low-pressure occurs very early in the stroke, viz., at about $4\frac{3}{8}$ inches.

Of course the cylinder ratios in these trials have been purposely chosen as different from each other as the design of the engines allowed, in order to show as definitely as possible the connection which subsists between cylinder ratio and the cut-off corresponding to highest efficiency. This paper does not profess to deal with the entirely distinct questions of the best cylinder ratios or the best total number of expansions for steam of different pressures. The particular values of the cylinder ratios used in these trials are therefore of no economic significance, except in so far as they are associated with the best cuts-off in the larger cylinders of the engines. And it is obvious that the more widely the experimental ratios differ from each other, the more clearly will their special connection with the point we are in search of be indicated. Hence the reason for the trials of Diagram VIII., and such an unusual ratio as 11 to 1.

An examination of the whole of these results shows that the one and

only factor which affects materially the cut-off of maximum economy in any one of the cylinders following the high-pressure cylinder is the ratio between the cylinder in question and the immediately preceding cylinder. In other words, the ratio between any two successive cylinders is the one factor which determines the point of maximum-economy cut-off in the second of the two cylinders.

In the subjoined table, column II. sums up the results from all the trials, in the shape of the best cut-off for each value of cylinder ratio (R). The figures in column III. represent maximum economy ratios

I. $\frac{\text{Any Cylinder Capacity}}{\text{Preceding Cylinder Capacity}}$ R.	II. Best Cut-off in Inches of Stroke.	III. $R \times \frac{\text{Best Cut-off}}{\text{Stroke}}$.
2·195	10½	1·28
2·195	10½	1·28
2·195	10½	1·28
2·195	10¾	1·31
2·195	10¾	1·31
2·296	10	1·275
2·296	11	1·4
4·86	6⅜	1·72
5·04	6⅝	1·85
11·00	4⅜	2·67

of free expansion in the receivers. These figures are therefore proportional to that receiver drop, with which is associated maximum economy in the several cases. The values in column III., when plotted to a base of R as in Diagram IX. (Plate XI.), will be seen to lie practically in a straight line. The equation to this line will be found to be as follows :—

$$R \times \frac{\text{Best cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6}.$$

From this follows the best cut-off in terms of R, viz.:—

$$\frac{\text{Best cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6\,R} = {\cdot}15 + \frac{1}{R}.$$

This last expression is an equation to a curve which is plotted in Diagram X. (Plate XII.), and from which diagram the best cut-off for any cylinder ratio can be read off by inspection, in fractions of the stroke. On the same diagram is shown, merely for comparison, the curve of cut-off for no receiver drop.

In the tabulated values of R, allowance is made for clearances, and also for areas of piston rods. By "best cut-off" is meant the particular cut-off in the larger cylinders at which maximum economy occurs.

It was very noticeable in the working of the engines that late cuts-off were distinctly conducive to smoothness of running, uniformity of turning moment, and durability of bearings; while early cuts-off were always accompanied by a comparative absence of these desirable qualities. With early cut-off in any cylinder the engines always appeared to labour heavily, and to work with jars and thumps, which symptoms entirely disappeared when the cut-off was increased. Owing to the absence of a fly-wheel any tendency towards inequality of turning was rendered very evident, and was, in addition, automatically recorded on the brake diagram.

Moreover, late cuts-off, being associated with smallness of valve travel, and all that this entails, are *constructively* preferable to early cuts-off. Late cuts-off also favour handiness in starting and reversing. From many points of view, therefore, it follows that late cuts-off are greatly preferable to early cuts-off. But—as shown by Diagram X. (Plate XII.)—late cuts-off, in the larger cylinders at least, can only be adopted with economy when the cylinder ratios are small. This leads to the conclusion that—other things equal—the most satisfactory engine as regards smoothness of working, durability, and economy in so far as affected by receiver drop, will be that engine which attains a given degree of total expansion with the smallest cylinder ratios, or at least with ratios not exceeding a certain limit.

It is necessary to bear in mind that although results are here given from double, triple, and quadruple expansion, no valid comparison can—on the results as they now stand—be instituted between these three methods of working. To institute such a comparison, all the different results must be reduced to a common basis as regards vacuum, barometer, steam pressure, etc., and this has not been done in the paper because not necessary for the purposes in view.

In Diagrams XI. to XV. (Plates XIII. to XVII.) inclusive, are given some samples of expanded indicator cards. These particular cards have been selected from a very large number in order to show the effects by contrast, of extreme variations in cut-off. The notes on the diagrams are sufficiently explanatory without further reference. The "mean pressure" on each card is that reduced to the low-pressure cylinder. It therefore represents comparative power in the several cylinders. It will be noticed that there is no marked evidence that maximum economy is associated either with equality of power, or with equality of temperature ranges in the several cylinders.

Deductions from the Results.—The following is a summary of the more important of the deductions which may be made from the results of the trials :—

1. For maximum economy of consumption, steam must be cut off at a certain point of the stroke in the larger cylinders of multiple expansion engines. For any given cylinder this point depends solely upon the ratio between the capacities of that cylinder and the preceding cylinder (R), and is expressed as follows, viz. :—

$$\frac{\text{Maximum-economy cut-off}}{\text{stroke}} = \cdot 15 + \frac{1}{R}.$$

This is the principal and most important conclusion deduced from the trials, and—as already explained—is embodied in Diagram X. (Plate XII.).

2. It follows from No. 1 that the cut-off in the larger cylinders, once fixed, should never be altered, whatever may be the cut-off in the high-pressure cylinder, or the steam pressure employed. This means that automatic-expansion governors, or linking-up gear, should act upon the high-pressure cylinder only, if maximum economy at all powers is to be preserved.

3. The cut-off in the larger cylinders affects materially the total horse-power developed by the engines. As regards the low-pressure cylinder of triples, and the second intermediate, and low-pressure cylinders of quadruples, maximum power cut-off in these cylinders coincides with the cut-off of maximum economy. As regards the second cylinder of triples and quadruples, maximum power cut-off is very considerably later than that of maximum economy. In compounds the maximum power cut-off in the low-pressure cylinder is only slightly later than that of maximum economy. See Diagrams I. to VIII. (Plates III. to X.).

4. When cylinder ratio (R) is small—say from 2 to 2·5—the cut-off in the larger cylinders may be varied considerably from that corresponding to maximum economy, without any appreciable fall in economy. But when R is large, there is no such permissible deviation, without entailing as a consequence a fall in efficiency. See Diagram VIII. (Plate X.).

5. With given efficiency in receiver drop, smallness of cylinder ratio is conducive to smoothness of working, uniformity of turning, durability, handiness in starting and reversing, and compactness of design.

List of Tables and Diagrams.

Table.	Diagram.*	Cylinders. Ins.	Ins.	Ins.	Pressure. Ins.	lbs.	
I.	I.	7	15½	23	—	210	H.P. cut-off 12″
II.	II.	7	10½	23	—	210	H.P. cut-off 12″
—	III.	10½	15½	23	—	120	H.P. cut-off 6″
—	IV.	10½	15½	23	—	120	H.P. cut-off 9″
—	V.	7	10½	15½	23	200	H.P. cuts-off 3″, 4½″, 6″, 12″
III.	VI.	7	10½	23	—	200	H.P. cut off 10″ Jacket trials.
IV.	VII.	7	10½	23	—	200	H.P. cut-off 10″ Receiver capacity trials.
V.	VIII.	7	23	—	—	200	H.P. cut-off 10″ Compound trials.
—	IX.	Receiver drop of maximum economy.					
—	X.	Cut-off of maximum economy.					
—	XI.	Expanded cards of No. 1, Table I.					
—	XII.	„ „ No. 5, „ I.					
—	XIII.	„ „ No. 5, „ II.					
—	XIV.	„ „ No. 9, „ II.					
—	XV.	„ „ No. 10, „ II.					

*See Plates III. to XVII.

Table I. (see Diagram I.).

Cylinders, 7 inches, 15½ inches, 23 inches, by 18 inches stroke. Intended boiler pressure, 210 lbs. Jacket steam shut off. Receivers continuously drained. Crank sequence H.I.L.

	Cut-off in Cylinders (Inches). H.	I.	L.	H.P. Steam-chest Pressure	Revolutions per Minute.	M.P. reduced to L.P.	I.H.P.	B.H.P. Brake Horse-power.	Water used per Hour.	B.H.P at 140 Revolutions.	Water per Hour at 140 Revolutions.	Water per B.H.P. per Hour.
				Lbs. per Sq. In.		Lbs. per Sq. In.			Lbs.		Lbs.	Lbs.
I. P. cut-off varied.	12	12	12	201	144·2	28·2	152·8	141·6	2,263	137·4	2,197	15·98
	12	10½	12	201	143·6	28·97	156	141·8	2,231	138·3	2,175	15·72
	12	9	12	200	148·1	28·96	161·2	145·9	2,258	137·9	2,134	15·47
	12	7½	12	201	147	28·76	158·8	144·5	2,209	137·6	2,104	15·28
	12	6	12	201·5	144·2	28·4	153·8	138·9	2,112	134·8	2,050	15·2
	12	4½	12	202·7	137·27	27·61	142·4	126	2,005	128·6	2,045	15·9
I. P. cut-off varied.	12	6	13½	201·7	144·63	28·97	157·3	141·7	2,166	137·2	2,096	15·28
	12	6	12	201	144·3	28 63	155·2	141·9	2,148	137·7	2,084	15·13
	12	6	10½	200·8	146	28·89	158·4	143·5	2,169	137·6	2,080	15·11
	12	6	10½	203	144·37	29·06	157·4	141·6	2,151	137·4	2 086	15·19
	12	6	9	202	146·8	29·3	161·5	143·8	2,177	137·2	2,076	15·13
	12	6	7½	201·8	144·6	29·25	159	139·1	2,145	134·8	2,077	15·42

TABLE II. (see Diagram II).

Cylinders, 7 inches, 10½ inches, 23 inches, by 18 inches stroke. Intended boiler pressure, 210 lbs. Jacket steam shut off. Receivers continuously drained. Crank sequence H.I.L.

	Cut-off in Cylinders (Inches)			H.P. Steam-chest Pressure	Revolutions per Minute	M.P. reduced to L.P.	I.H.P.	B.H.P. Brake Horse-power.	Water used per Hour.	B.H.P. at 140 Revolutions.	Water per Hour at 140 Revolutions.	Water per B.H.P. per Hour.
	H.	I.	L.	Lbs. per Sq. In.		Lbs. per Sq. In.			Lbs.		Lbs.	Lbs.
I.P. cut-off varied.	12	13½	10½	198·5	144·8	27·57	149·5	137·5	2,102	133	2,033	15·29
	12	12	10½	200	145·4	27·88	152·1	136·4	2,087	131·3	2,009	15·3
	12	10½	10½	202	142·17	27·62	147·6	132·2	2,026	130·2	1,995	15·33
	12	9	10½	201	139·6	26·96	141·2	126·3	1,938	126·6	1,943	15·34
L.P. cut-off varied.	12	11½	12	201	136·06	27·06	138·3	124·7	1,975	128·4	2 033	15·82
	12	11½	10½	201	137·9	27·57	142 6	127·6	1,996	129·6	2,026	15·64
	12	11½	9	202	139·63	27·94	146·5	131·6	2,016	131·9	2,021	15·32
	12	11½	7½	202	141·2	28·48	151	135·6	2,024	134·4	2,006	14·92
	12	11½	6	202	142·47	28·55	152·7	138 3	2,028	135·8	1,992	14·67
	12	11½	4½	200	139·6	27·43	143·8	131·8	2,004	132·2	2,010	15·2

TABLE III. (see Diagram VI.).

Cylinders, 7 inches, 10½ inches, 23 inches, by 18 inches stroke. Intended boiler pressure = 200 lbs. Steam on jackets. Receivers not drained. Crank sequence H.I.L.

Cut-off in Cylinders (Inches).			H.P. Steam-chest Pressure	Revolutions per Minute.	M.P. reduced to L.P.	I.H.P.	B.H.P. Brake Horse power	Water used per Hour.	B.H.P. at 140 Revolutions.	Water per Hour at 140 Revolutions.	Water per B.H.P. per Hour.
H.	I.	L.	Lbs. per Sq. In.		Lbs. per Sq. In.			Lbs.		Lbs.	Lbs.
10	10½	10	197	137·34	29	149·9	130·5	2,013·5	133	2,053	15·43
10	10½	8	198	146·7	28·91	159·1	144	2,151	135·4	2,052	15·15
10	10½	6	196	142·55	29·93	160	141·2	2,033	138·6	1,997	14·4
10	10½	6	197	135·5	29·02	147 5	131·6	1,971·2	136	2,037	14·97
10	10½	4	200	140 8	29 18	154·1	136·3	2,064·4	135·6	2,052	15 13

TABLE IV. (see Diagram VII.).

Cylinders, 7 inches, 10½ inches, 23 inches, by 18 inches stroke. Intended boiler pressure = 200 lbs. I.P. receiver doubled in capacity as compared with Table II. Jacket steam shut off. Receivers continuously drained. Crank sequence H.I.L.

Cut-off in Cylinders. (Inches).			H.P. Steam-chest Pressure	Revolutions per Minute.	M.P. reduced to L.P.	I.H.P.	B.H.P.	Water used p r Hour.	B.H.P. at 140 Revolutions.	Water per Hour at 140 Revolutions.	Water per B.H.P. per Hour.
H.	I.	L.									
			Lbs. per Sq. In.		Lbs. per Sq. In.			Lbs.		Lbs.	Lbs.
10	13½	6½	197·5	139	25·86	134·8	123·5	1,963·6	124·4	1,979	15·91
10	12	6½	197·5	139·53	25·82	135·2	124·9	1,967·3	125·4	1,973	15·74
10	10	6½	197	138·23	25·99	134·8	121·8	1.885	123·4	1.909	15·46
10	8	6½	198	136·14	25·74	131·4	117·7	1,815·6	121	1,867	15·43

NOTE.—Vacuum was exceptionally low for trials on Table IV.

TABLE V. (see Diagram VIII.).

Cylinders, 7 inches, 23 inches, by 18 inches stroke. Intended boiler pressure, 200 lbs. Jacket steam shut off. Receivers continuously drained. Cranks at 90 degrees, L.P. leading.

Cut-off in Cylinders (Inches).		H.P. Steam-chest Pressure	Revolutions per Minute.	M.P. reduced to L.P.	I.H.P.	B.H.P. Brake Horse-power.	Water used per Hour.	B.H.P. at 140 Revolutions.	Water per Hour at 140 Revolutions	Water per B.H.P. per Hour.
H.	L.									
		Lbs. per Sq. In.		Lbs. per Sq. In.			Lbs.		Lbs.	Lbs.
10	7½	197	127·9	22·52	108	101·5	1,970	111·1	2,156	19·4
10	6	199	132·2	23·73	117·7	108·3	2,000	114·7	2,118	18·46
10	4½	198	131·23	24·15	118·9	107·6	1,950·6	114·8	2.081	18·13
10	3	199	130·7	21·63	106·1	103·2	1,874	110·5	2·007	18·16

The PRESIDENT, in adjourning the meeting, said they were going to have two extra meetings this session. They had got so many papers and so much material for discussion that they were driven to have extra meetings, which, he hoped, would be gratifying to them as showing the great interest taken in the affairs of the Institution.

The meeting then dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

FOURTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, FEBRUARY 2ND, 1900.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Newcastle-upon-Tyne, on January 19th, which were approved by the members present and signed by the President.

The discussion on Prof. R. L. Weighton's paper on "Receiver Drop in Multiple Expansion Engines" was opened and closed.

Mr. S. J. P. THEARLE read a paper on "The Distribution of Materials in the Upper Works of Large Steamers."

DISCUSSION ON PROF. R. L. WEIGHTON'S PAPER ON "RECEIVER DROP IN MULTIPLE EXPANSION ENGINES."

Mr. F. W. JENNINGS said Prof. Weighton stated that his paper did not profess to deal with the questions of the best cylinder ratios or the best total number of expansions; but as the formula deduced from the experiments depended entirely on the cylinder ratios, it appeared to him that it was of very little assistance unless they had some idea of the best cylinder ratios.

One of the most noteworthy points indirectly raised by the paper was the inefficiency of the steam jackets. On comparing Tables II. and III, pages 70 and 71, Diagrams II. and VI. (Plates IV. and VIII.) it would be seen that the saving obtained from the use of steam jackets was only ·27 lbs. of water per brake horse-power per hour. This was exceedingly small, and it would be both interesting and instructive if they could have some explanation for it.

On page 69, deduction No. 2, was the following:—"This means that automatic expansion governors or linking-up gear should act on the high-pressure cylinder only if maximum economy at all powers was to be preserved." Were they to assume from this that Prof. Weighton recommended separate linking-up, because, if so, it did not agree with his remarks on the paper on "Cylinder Ratios," by Mr. James Andrews,* in which he said that he did not think any system of linking-up separately would secure a satisfactory result. It would be interesting to know whether the results of the experiments described in the present paper had made him change his mind, or whether practical considerations outweighed the theoretical.

The table on page 67 gave the ratio R of any cylinder capacity to preceding cylinder capacity; but he thought it would have been clearer if it had been specified in each case whether the ratio of the intermediate-pressure cylinder to the high-pressure or the low-pressure to the intermediate-pressure was meant. He had prepared a table (Table VI., page 76), in which the ratios were given separately, with the corresponding actual best cuts-off in percentages of stroke, and also the calculated best cuts-off from the formula given He had assumed that the fixed cuts-off were the best, as they came so near those

* *Transactions of the North-East Coast Institution of Engineers and Shipbuilders*, vol. xiv., page 222.

obtained by the formula. As he had not the particulars of areas of piston rods, etc., he had had to work simply on the areas of cylinders, thus making his figures appear slightly different to those given in the paper, but the difference was scarcely sufficient to be of any practical importance. This table only tended to prove, if such proof were necessary, how accurately the formula represented the results obtained from the experiments, the greatest variation being only about 4 per cent, the majority being within 2 per cent.

He had prepared another table (Table VII.) from actual valve settings of marine engines of varying sizes, in normal gear, the high-pressure cylinders varying from 10 inches diameter to over 30. In this table it would be seen that there was a very considerable difference between the actual cuts-off and the calculated best cuts-off, in some cases as much as 20 per cent. Were they to understand that these engines were badly designed, or were there other reasons for this difference which the formula did not cover?

TABLE VI.

Cylinder Ratios.			Actual Best Cut-off in Percentage of Stroke.			Calculated Best Cut-off in Percentage of Stroke by Prof. Weighton's Formula.		
I.P.$_1$ to H.P.	I.P.$_2$ to I.P.$_1$	L.P. to I.P.	I.P.$_1$	I.P.$_2$	I.P.	I.P.$_1$	I.P.$_2$	L.P.
4·901	—	2·202	36·8	—	58·4	35·6	—	60·6
2·25	—	4·797	61·2	—	35·4	59·6	—	36·0
2·178	—	2·202	59·8	—	59·8	61·2	—	60·6
2·178	—	2·202	59·8	—	59·8	61·2	—	60·6
2·25	2·178	2·202	58·4	58·4	58·4	59·6	61·2	60·6
2·25	—	4·797	58·4	—	31·95	59·6	—	36·0
2·25	—	4·797	55·5	—	36·1	59·6	—	36·0
—	—	10·795	—	—	24·3	—	—	24·4

TABLE VII.

Cylinder Ratios.		Actual Cut-off in Percentages of Stroke.						Calculated Best Cut-off in Percentages of Stroke by Prof. Weighton's Formula.	
		I.P.			L.P.				
I.P. to H.P.	L.P. to I.P.	Top.	Bottom.	Mean.	Top.	Bottom.	Mean.	I.P.	L.P.
2·625	2·667	63·2	53·2	58·2	63·2	55·7	59·45	53·25	52·7
2·813	3·062	70·9	62·25	66·57	70·6	63·3	66·45	50·75	47·8
2·729	2·576	62·8	53·5	58·15	65·5	58·4	61·95	51·8	54·1
2·665	2·874	61·5	51·4	56·45	59·8	54·7	57·25	52·7	49·9
2·65	2·67	62·0	52·4	57·2	63·0	56·0	59·5	52·9	52·75
2·662	2·963	68·4	59·2	63·8	67·6	58·8	63·2	52·8	48·9

TABLE VIII.

Cylinder Ratios.	Actual Cut-off in Percentage of Stroke.			Calculated Best Cut-off in Percentage of Stroke by Prof. Weighton's Formula.
	L.P.			
L.P. to H.P.	Top.	Bottom.	Mean.	L.P.
3·21	63·2	56·2	59·7	46·4
2·56	63·75	56·25	60·0	54·25
4·86	58·8	51·8	53·3	35·75
2·94	67·5	62·25	64·875	49·25

He had prepared a third table (Table VIII.) from actual valve settings of high-speed compound engines, in which the difference between actual cuts-off and calculated best cuts-off was still more marked. He would refer more particularly to the third example given in this table, in which it would be seen that the difference between the actual cut-off and the calculated best cut-off was nearly 20 per cent. Yet this engine was known to work with a steam consumption of less than 15 lbs. per indicated horse-power per hour. It appeared from this that the actual point of cut-off was of less importance than the paper led them to believe, and that a very considerable variation might be made without affecting the economical working of the engine.

In the paper nothing was said about the difference in cut-off between the top and bottom of the cylinders. How did a considerable difference affect the results? In Tables VII. and VIII. he had given the cuts off for both top and bottom of the cylinders, and it would be seen that in some of the marine engines there was as much as 10 per cent. difference. In the high speed engines the difference was not so marked. He thought that particulars of the valve settings, or at any rate of the top and bottom cuts-off of the engines used in the trials would be interesting, if they could be given them. It appeared to him that when marine engine valve gears were laid down very little consideration was given to this point He knew that in locomotive valve setting it was considered very important, and much time was often spent in making the cuts-off as equal as possible, the position of the reversing shaft playing a very important part, whilst so far as he (Mr. Jennings) could make out, each firm of marine engine builders had its own particular rule for settling the position of the reversing shaft, which it invariably worked to; but, as settling the position of the reversing shaft by the rules of two different firms would sometimes make a difference of over a foot, it stood to reason that one must be better than the other. He was therefore of the opinion that it would pay marine engineers to devote

more attention to this point. It would, of course, necessitate the laying down of the point paths of the gear if a large scale model was not available, but as these showed very clearly the path of each part of the gear, they were to be preferred to a valve diagram in any case. He knew from experience in locomotive work that a slight alteration in the position of the reversing shaft often made a very considerable difference in the results.

Mr. Robert M. Ferrier, B.Sc., said he had scarcely intended to speak on the paper at all, as it seemed to him that the points intended to be brought forward were fully and clearly explained in the paper itself. He thought the paper clearly showed that it was intended to give an account of some experiments undertaken with a definite object in view, namely, the determination of the best point of cut-off in the larger cylinders of multiple expansion engines. But apparently there had been some misunderstanding of the object of the paper. One of the larger weeklies* (*The Engineer*) devoted an article to it, in which it found fault—first, on the ground that the paper did not provide an adequate theory of steam engines on the whole; and next proceeded to insist that the results did not apply to engines in general, but only to those on which the experiments were actually made at the College of Science. As he (Mr. Ferrier) understood it, the object of these experiments was simply to determine one particular point, viz., at what particular point of the stroke in larger cylinders was it best to cut-off the steam with regard to maximum economy? Hitherto it had been assumed in designing engines that the best cut-off in the later cylinders would be determined by arranging them so that the powers produced in the different cylinders should be about equal.

At different pressures also, it might be thought better to vary the cut-off as higher or lower pressure was used. The total ratio of expansion used in the whole engine might also influence the point of cut-off in the different cylinders.

Well, the paper gave an account of experiments undertaken with the object of settling the question by actual trial, and showed that the same point of cut-off was found to be most economical, whether high or low pressure was used, pressure of 120 lbs. or a pressure of 210 lbs. The best cut-off was found to be at one particular point in each cylinder. Then, again, the receiver capacity was varied, and that also was found to have no effect; and finally, the only point, the only factor, that

* See *The Engineer*, vol. lxxxix., page 96.

seemed to have any influence upon the point of cut-off for maximum economy, was the ratio of cylinder capacity. Now, as the range of variation of cylinder capacity was from little more than double the preceding to 11 times, which exceeded any ratio common in practice, he did not think it could be said very well that the results of the experiments were confined to one particular set of engines. It was impossible to conceive any special construction which would affect the cut-off other than those laid down in the paper, and seeing that the results had shown that the cylinder capacity, and that only, affected the best point of cut-off, he thought they might assume that these results would apply to all engines and not only to those upon which the experiments were actually made.

Mr. Edwin Griffith said he was tempted to take part in the discussion from the opinions expressed on the paper in *The Engineer*. He must confess he was quite staggered when he read the article in *The Engineer*. His attention was drawn to this production, and he thought it peculiarly incapable. The writer of the article, he fancied, never read the paper he was discussing—never thoroughly, certainly. He supposed it was a principle in journalism not to read what they were going to review. The main point made by the writer in *The Engineer* was that these experiments showed what was best for the college engine, and for that only. If these experiments were conclusive for the college engine they seemed to him to be so practically for all other engines. The real question was whether they were conclusive for the college engines. But, assuming that they were so, as put in *The Engineer*, then he thought they must apply generally. The particular point experimented upon was tried under all possible variations of the essential conditions. Any compound engine he knew of came practically within the range of the experiments. They were experiments, not under a particular condition, but with a great variation of conditions; that is, every vital factor was varied—the total ratio of expansion, the number of cylinders, the receiver capacity, the steam pressure—and all these were found to have no influence on the particular point which the experiments were made to determine. However, the real question was, were the experiments exhaustive? His own feeling, broadly, was that they were exhaustive, except, possibly, upon the point of the effect of receiver capacity. He presumed that these tables represented the results of more experiments than those alluded to: that they were typical—because he thought a great many experiments were necessary for one result—to correct errors

of observation; but the results of more experiments on receiver capacity would have been of value. If anyone had a fad on that question, then he did not think Prof. Weighton had produced sufficient evidence to refute such a man. The article in *The Engineer* was hardly worth referring to further, but there were one or two points in it which he might mention, but would not discuss or waste their time upon. It said, among other things, that the receiver drop might be eliminated altogether. Well, he thought the writer would be better employed doing so than writing such articles. Then it said that the indicator cards did not represent the power developed in the cylinders. He did not know what that really meant; but perhaps someone more in the confidence of *The Engineer* might inform them. To an outsider it needed some explanation. There were other points, but the tendency of those alluded to was not to inspire them with confidence in the writer. He thought the Institution was to be congratulated upon such a paper as this from Prof. Weighton, which he considered was of great practical value.

The SECRETARY read the following communications on the paper:—

GLASGOW, *January 30th*, 1900.

DEAR MR. DUCKITT,

I have read with much interest Prof. Weighton's paper on "Receiver Drop in Multiple Expansion Engines." There is an old saying that an ounce of practice is worth a pound (or is it a ton?) of theory, and we have in these experiments, so thoroughly carried out and clearly set forth, a weighty addition to our practical knowledge of the action of steam in modern engines. Some time ago, when Prof. Weighton gave us the results of his experiments on the economy as affected by the total number of expansions, it was a gratification to the practical engineers responsible for the designing and running of marine engines respectively to find their experience that a relatively high mean pressure was at least not less economical than a low one borne out entirely by those experiments, and this against the generally accepted theory of economy in number of expansions. Now, again, practice gets a help against the theory that the greatest economy is to be sought in "no receiver drop." The experiments, if they proved nothing further than this, would be of great value, but the range of cylinder ratios which have been tested is so considerable that it has been possible to deduce a rule for the most economical point of cut-off in the following cylinders. It is to be noted that this cut-off points to small ratios of cylinders, which also follows

from the use of relatively high mean pressures, and thus vindicates the correctness of the practical mean estimate of the size of an engine which depends on the size of the *high*-pressure cylinder. Dare I ask how this bears on the North-East Coast Normal Horse-power Rule?

I notice an article in this week's *Engineer* on Prof. Weighton's paper, in which the writer says:—"But we have no reason to assume that the deductions legitimately drawn by Prof. Weighton will apply to other engines of different proportions." And further on, "Now, we venture to say that the formula quoted above will not necessarily hold good of any other engine working under somewhat different conditions." To me it appears we are quite justified in drawing the conclusions to which the writer quoted demurs. It is to be remembered that the experiments have been made *not* on one engine, but upon a series of engines of very various proportions, and the results show the effect of the variation of proportions within their wide limits, and certainly indicate what the effect of further variation would be. The writer in *The Engineer* has, in my opinion, underestimated the value of the experiments; for instance, in one place he says:—"The triple expansion engine tested has cylinders 7 inches by 15½ inches by 23 inches by 18 inches," and makes no reference to the other triple expansion engine tested—the wide variation in the ratios of the cylinders of the two engines being a *feature* of the experiments. Again, after telling us that no useful working theory of the action of steam in an engine exists, he tells us that, "According to all known laws of physics, the free expansion of steam into the receiver cannot represent a loss, since no waste of work is done." I quote these to show what a need there is of just such experiments as those made by Prof. Weighton, which clearly show that a variation of receiver drop causes variation of efficiency, and point out for given cylinder ratios what is the most economical drop.

Yours faithfully,

JAMES PATTERSON.

OBAN HOUSE, HIGH LANE,
CHORLTON-CUM-HARDY, MANCHESTER,
January 31*st*, 1900.

DEAR MR. DUCKITT,

The paper on "Receiver Drop in Multiple Expansion Engines," read by Prof. Weighton, is of great practical importance and ought to prove of immense service to those engaged in the design and manufacture of multiple expansion steam engines. I have, on various occasions, spent a considerable amount of time in analysing and drawing diagrams relating

to many of the trials given in the paper, and I trust that the following remarks, which seem to me as giving a fairly reasonable explanation of some of the results, will be acceptable to the members of the Institution.

It is extremely important, in order to obtain a clear understanding of the conclusions arrived at, that the two factors entering into the question of economy, namely, the water used and the horse-power, should be at first considered separately. When we have discovered, firstly, why the feed in a triple expansion engine, say, alters as the cut-off in the intermediate-pressure cylinder is varied, and, secondly, why the horse-power alters at the same time, the explanation of the experimental results becomes simple.

In Trial 6, Table I., page 70, the water consumption is 2,045 lbs. per hour at 140 revolutions, and in Trial 1 the water is 2,197 lbs. at the same revolutions, an increase of 152 lbs. per hour. That is to say, a greater amount of steam entered the high-pressure cylinder at every stroke during Trial 1 than entered during Trial 6, although the cut-off in the high-pressure cylinder was in both cases fixed at the same point. The feature of difference in the two trials, to which was due the variation in the feed, lay in the fact that in Trial 1 the intermediate-pressure cylinder cut-off was later than in Trial 6.

Now, a later cut-off in the intermediate-pressure cylinder means a lower first receiver-pressure, and consequently, a lower temperature of the high-pressure exhaust steam. The effect of this is to lower the mean high-pressure cylinder wall temperature and consequently to increase the initial condensation in that cylinder. Part of the increased consumption, and probably the greater part will be due to greater leakage past the high-pressure slide valve into the exhaust.* This is due to the fact that the pressure difference between the steam in the high-pressure steam chest and that in the first receiver becomes greater as the point of cut-off in the intermediate-pressure cylinder is made later. These two causes combined, condensation and leak, seem to account for the fact that the missing quantity (the difference between the steam consumption indicated by the card and that actually passing through the engine) increases as the point of intermediate-pressure cylinder cut-off becomes later. I have brought this fact before the notice of the Institution on previous occasions, illustrating it by results obtained from experiments made by me at McGill University.

* See paper on "Multiple Expansion Engines," *Transactions Royal Society of Canada*, 1896-97.

When we consider the question of high-pressure we find that, up to a certain point, the later the cut-off in the intermediate-pressure cylinder is made, the greater is the horse-power developed. This may be partly due to the re-evaporation of water initially condensed in the high-pressure cylinder and also to increased card area, the result of less temperature range and less wire-drawing at admission in the intermediate-pressure cylinder. The effect that early cut-off has upon the area of a card is seen by superposing the diagram from the 15½ inch cylinder in Prof. Weighton's engine used as a triple with cylinders 7 inches, 15½ inches, and 23 inches, upon the cards from the 10½ inches and 15½ inches cylinder when used in the quadruple engine with cylinders 7 inches, 10½ inches, 15½ inches, and 23 inches. When the point of cut-off in the high-pressure cylinder is the same in both cases and the *volume* at cut-off in the 15½ inch cylinder is the same as that in the 10½ inch cylinder, we might expect the admission pressure in the 15½ inch cylinder of the triple to be equal to that of the 10½ inches in the quadruple. It will be found, however, that the card showing the expansion carried out in the one cylinder with the early cut-off shows a considerable loss when compared with the cards showing the expansion carried out in two cylinders. I prepared a diagram to illustrate this point some time ago, but regret that I cannot at present lay hands upon it. When we make the cut-off in the intermediate-pressure cylinder later than a certain point, the horse-power becomes smaller. This is most probably due to the reduction in card area, as seen in combined diagrams, from the excessive drop at release in the high-pressure cylinder. Of course the reasoning I have given above refers solely to the changes in the indicated horse-power. The brake horse-power must, in addition, be altered by such effects as Prof. Weighton observes on page 68. If we neglect, then, for the time, the consumption, and consider only the power developed, we see that there is one particular point of cut-off in the intermediate-pressure cylinder which gives the most power. To cut off earlier than this point means loss by excessive condensation in the cylinder or wire-drawing of the steam during admission, to cut off later means loss by excessive drop between the high-pressure and intermediate-pressure cylinders. If, therefore, the consumption increases as the intermediate-pressure cut-off becomes later, and the horse-power attains a maximum and then diminishes, there must be some best point of cut-off where we shall use the least water per horse-power per hour.

The reason why a later cut-off in the low-pressure cylinder increases the consumption must also be due to the fact that a late cut-off in the low-pressure has the effect of lowering the pressure in the first receivers. This can be seen by comparing Diagrams 13 and 15 (Plates XV. and XVII.). The rate of increase of the feed is, however, smaller than when the changes are made in the intermediate-pressure cylinder, as the alterations in the first receiver pressure are now merely a secondary effect.

I have used diagrams similar to Nos. 9 and 10 (Plates XI. and XII.) to help me in fixing cylinder ratios, as follows:—I first fixed up on the total expansions required, and assumed a ratio of cylinders, taking account of engines previously made. The points of cut-off were then fixed from a diagram similar to No. 10, and the probable expanded cards drawn. With previous engines to go upon, one can quickly get an approximate card that will not be very different from what would obtain in practice. I then tried what initial loads this arrangement gave on the pistons, and if they were unequal in the different cylinders I fixed upon other ratios, and tried them again. In this manner it is possible to fix upon a ratio of cylinders that will work well, and to know that although it may not be the very best so far as water per horse-power is concerned, yet if the points of cut-off are fixed according to Diagram 10, it must be very near the best. I entirely agree with Prof. Weighton when he mentions that there is no marked evidence that maximum economy is associated with equality of powers or equality of temperature ranges in the several cylinders. The temperature range of the high pressure cylinder is the only one that can have any marked effect upon the consumption, and should be kept as small as possible.

Trusting that these remarks may prove of interest, and tend to produce further discussion.

Yours faithfully,

A. L. MELLANBY.

PROF. WEIGHTON'S REPLY.

Prof. WEIGHTON, replying to the discussion, asked first of all to be allowed to say how much obliged he was personally to those who had taken part in the discussion, and especially to those who had sent written communications. He would deal with the different speakers in their order.

Mr. Jennings had contributed three tables, which were numbered VI., VII., and VIII., pages 76 and 77. In the first table occurred the heading, "Actual best cut-off." He would like, before proceeding further, to ask what were the means employed to find the "best" cut-off in the several engines referred to?

Mr. JENNINGS—I took the cuts-off as shown in the indicator diagrams.

Prof. WEIGHTON—The cuts-off tabulated as "best" Mr. Jennings had obtained from measurement of the indicator diagrams. Because they were the "actual" cuts-off, Mr. Jennings had apparently assumed they were also the "best." This, of course, did not by any means follow, else there would be no need for experimenting on the subject. He (Prof. Weighton) would submit that the cuts-off in Table VI. should not be called "best," but simply "actual" cuts-off. Nothing whatever could possibly be learned from inspection of indicator diagrams in regard to the best cut-off. The "best" cut-off was that cut-off with which was associated the minimum quantity of steam per brake horse-power, and it was obvious neither the steam used nor the brake horse-power could be obtained from indicator diagrams. He failed to see, therefore, that Mr. Jennings' tables proved anything whatever. They could only serve to show how near practice in some cases had approximated to the formula of the paper, and how far in other cases it fell short of it. The precise object and meaning of some of Mr. Jennings' remarks were difficult to understand. Like the writer in the *Engineer* (referred to later on), he would seem to prefer to have the entire question of the steam engine as a whole solved completely and at once without further delay. He was not content to have the difficulties tackled one by one. He said that the "formula was of very little assistance unless they had some idea of the best cylinder ratios." The question of the best cylinder ratio, or whether there was any "best," had not yet been solved, and before its solution could even be approached it was absolutely necessary that the best cut-off in the larger cylinders should be known. But independent of this, engines must in the meantime be built having some particular cylinder ratios, and surely a knowledge of how to get the most out of any given ratios—be they the best or the worst—must be of considerable assistance to a designer. Again he said, "One of the most noteworthy points raised by the paper was the inefficiency of the steam jackets." Now this was precisely one of the points which was *not* raised by the paper. Like many other points, it was subject of an inquiry

entirely different from the avowed object of the paper. No comparison could be made between Tables II. and III., page 71, because the conditions were not identical. In Table II. the steam pressure was 210 pounds, the high-pressure cut-off was 12 inches, and the receivers were drained; while in Table III. the pressure was 200 pounds, the high-pressure cut-off was 10 inches, and the receivers were not drained at all. Variations such as these affected the results in a comparative sense very seriously, and quite invalidated any conclusions drawn as to jacket efficiency under the circumstances.

In the paper read by Mr. James Andrews, linking-up was recommended when necessary, in the second and third cylinders of triples, to secure equality of powers. In the paper before us, linking-up in these cylinders was shown to be incompatible with maximum economy, assuming that the cuts-off were suitably arranged with this object to begin with. He failed to discern any inconsistency here between what he had said in discussing Mr. Andrews' paper and the results of the present paper.

Mr. Jennings asked a question with regard to the engines in his Table VII. The answer was that in as far as these engines were not working with the cuts-off prescribed by the formula, they were working at less than maximum economy in the circumstances. With regard to the third example in Mr. Jennings' Table VIII., which engine was said to require 15 lbs. of water per indicated horse-power, how did Mr. Jennings know that this engine would not have been improved in consumption had the low-pressure cut-off been arranged according to the formula? Had this cut off been at 36 per cent. instead of 53 per cent., the water consumption would have been lowered from 15 lbs. to about 14·4 lbs. This is the amount of saving which was shown by the results of the paper in a similar case. He (Prof. Weighton) did not think any useful purpose would have been served by giving the cuts-off top and bottom of the cylinders. Such details would probably only have served to obscure the real issues of the paper, and he had purposely omitted all such.

He was obliged to Mr. Ferrier and to Mr. Griffith for their comments. He was specially beholden to the latter gentleman, for the very scathing and convincing criticism to which he had subjected their friend the writer of the article in the *Engineer*. After what had been said by the several speakers, he did not intend to further deal with the article in question, except to say that it had never occurred to himself that there was any need for justifying the implication in the

paper that the results were legitimately applicable to other engines. The results were relative, not absolute—qualitative, not quantitative—and this being so, they were fairly applicable to all engines not differing from the experimental engines in any essential or vital feature.

Mr. Griffith's doubts as to the sufficiency of the experiments in regard to receiver capacity he could quite understand, seeing that only one variation was made in this condition. He thought, however, he was quite justified in drawing the conclusion he did in the paper. Examination of the curves of water per brake horse-power in Diagrams II. and VII. (Plates IV. and IX.) showed these curves to be of the same general character, and if a doubled capacity had no material effect, he did not see how a capacity increased in any other ratio—within the limits of practice—could be expected to have a material effect. Further, in practice most engines would fall within the limits of the experiments, very few indeed having smaller receivers than that in use in Diagram II., and none having larger than that in Diagram VII. For these reasons he concluded he was justified in not pursuing the point further than he had done in the trials recorded. He might mention that the results given in the tables did not by any means represent the whole of the work which had been done in connection with this question of cut-off in the larger cylinders. Over 160 individual trials, each of from half an hour to one hour duration, had been made with the view of solving this one point.

Mr. Patterson asked how the results bore on the normal indicated horse-power rule. He (Prof. Weighton) had given no consideration to this aspect of the question, but so far as he could see at the moment, he thought there was at least nothing in them inconsistent with the basis of the rule referred to.

With the observations contained in Mr. Mellanby's communication he entirely agreed. This was a subject of which Mr. Mellanby had made a special study, on engines both in this country and in Canada, and his remarks well deserved careful consideration.

The PRESIDENT was sure they would join him most heartily in giving a sincere vote of thanks to Prof. Weighton for his paper. It would carry them forward in their knowledge of engines, and give them something for study.

The vote was accorded by acclamation.

THE DISTRIBUTION OF MATERIALS IN THE UPPER WORKS OF LARGE STEAMERS.

By SAMUEL J. P. THEARLE, Principal Surveyor to Lloyd's Register, Newcastle-upon-Tyne.

[Read before the Institution, in Newcastle-upon-Tyne, on February 2nd, 1900.]

The growing tendency to build very much larger cargo steamers than formerly, and to place extensive superstructure upon them, has rendered it necessary to give increasingly careful attention to the distribution of the materials throughout their upper works.

In some cases these extensive erections are intended as permanent shelters for cattle or horses, while in other cases the multiplication of superstructures are due to circumstances having more relation to laws for tonnage measurement than to any other cause. But whatever may be the reasons which will account for vessels being built so much larger than formerly, or for their being surmounted with shelter decks, long bridge houses or the like, the fact remains that these are the kind of vessels we now have a very great deal to do with, and in the upper works of which a suitable distribution of materials is required.

Until a comparatively recent period it was considered proper to view the upper deck of a vessel with its sheer strake, stringer and deck plating as the upper member of a floating girder, and any erections built upon it were considered of sufficient strength if able to resist blows from the sea.

The chief function of the bridge house, then, was to cover the engine and boiler openings, afford space for officers' rooms and stow some bunker coal. It was, therefore, made of no greater length than was necessary in order to fulfil those purposes and, as a consequence, it covered but a small fraction of the vessel's length.

It was not considered that such a short erection as this could contribute much towards the strength of the floating structure, and hence no attempt in that direction was made.

Only in vessels of great proportion of length to depth was a structure covering half the mi lship length required, and this erection had to be of a substantial character in order that the materials in it might be really contributory to the vessel's longitudinal strength, by deepening her effective girder within that half-length. But during recent years causes have operated tending to considerably increase the lengths of the superstructures on the upper decks of, not only exceptionally long vessels, but also of those having ordinary proportions.

Without discussing these causes, it may be said that some of them are such as should in no way influence the design of merchant steamers, although under present conditions it is inevitable that they must do so.

It is to be regretted that the designs of vessels should be based, not upon what is intrinsically good, but upon that which tonnage laws make profitable. Fortunately, however, in the cases of shelter decks and long bridge houses the outcome is good, and it would be better were it not that tonnage laws encourage unenclosed spaces where enclosed ones would be preferable.

In order that long bridge houses may be able to resist the stresses which come upon them, as the upper members of a girder, it has been found necessary to make them of stronger scantlings than were given to the short bridge houses formerly fitted, and even relatively short bridge houses have been found to need scantlings and riveting in excess of what was formerly thought sufficient. In various ways the fact has been impressed upon the shipbuilder that the materials in a structure raised upon the upper deck of a steamer must experience even a greater intensity of stress per unit of sectional area than those of the deck upon which it stands and to which it is attached. This is the case when the superstructure does not extend to the sides of the vessel, and is still more marked when it does.

The time has passed when such deck erections would be constructed of teak only, and be supposed suitable for the accommodation of passengers on an ocean voyage of several weeks' duration.

Nor is it likely that satisfaction will again be found in an arrangement which saves such superstructures from straining and leaking by cutting them wholly across and allowing the parts to work freely among themselves; even although watertight sliding joints may be provided. These things, as is well known, have been done in the past, when experience was not so large or as correctly informed as it now is.

To-day there is no excuse for compromises or failures of that kind. It is within the capabilities of shipbuilders to erect superstructures as long as an owner's requirements may demand, and to build them with gangway doors and other openings to suit the necessities of his trade, while at the same time making them integral parts of the vessel, and rendering the entire structure the stronger for their presence.

Shelter decks and awning decks may, indeed, be valuable elements of strength to a vessel as they have always been of seaworthiness, and only so far as the strength of such erections falls short of that of a normal upper deck with its associated side plating and framing, just so far need the height of freeboard be increased in a laden vessel when such erections are fitted.

The value of such superstructures will, therefore, be especially evident in the cases of vessels wherein stowage capacity is of more importance than deadweight carrying capability, as in cattle ships or those which carry meat in refrigerating chambers.

Viewed in comparison with the temporary wood protection usually provided when cattle is carried on an upper deck, the provision of a shelter deck has everything to commend it, and in vessels bringing frozen mutton and beef from South America and the antipodes, the unmeasured space between the shelter and upper decks can always be advantageously filled with light goods and bunker coal.

That economical advantages are found in the use of this type of vessel is evident from the great number of them that have recently been built and the many that are still in hand. Similar reasons will account for the many vessels having part shelter decks, and for those with lengthy but disconnected deck erections which always include a long bridge house.

Attention has been forcibly directed of late to cases in which stresses that might not have been of sufficient intensity to deform the materials of a steel upper deck have yet given rise to much deformation in the materials of shelter, awning and bridge decks. In one vessel with a cambered keel, which was docked upon hard, straight blocks, it was found that the originally smooth and fair shelter deck plating was buckled to a depth of $1\frac{1}{2}$ inches between two consecutive beams, at a frame spacing apart, at about the middle of the vessel's length. When the vessel floated, a half of the buckle came out, and the whole was subsequently removed. And yet the most careful sighting showed a vertical change of form of only $2\frac{7}{8}$ inches in a length of 400 feet between the dry docked and the floating condition of the vessel.

In another case of a vessel having a cambered keel, docked upon hard straight blocks, it was found that a part awning deck was buckled to a depth of $1\frac{5}{8}$ inches between two consecutive beams at a frame spacing apart.

Upon sighting the deck when the vessel was on the blocks, and afterwards afloat, it was found that a vertical change of form of only $1\frac{1}{4}$ inches in a length of 240 feet was capable of producing so deep a buckling in the plating as $1\frac{5}{8}$ inches.

In both these cases a portion of the camber of the keel was accounted for by the latter being embedded at its extremities in the cap blocks, so that only $2\frac{7}{8}$ inches in one case and $1\frac{1}{4}$ inches in the other were operative in producing the buckle in the deck plating.

In yet another case a tie plate in a bridge deck was set down $\frac{3}{8}$ inch below the wood deck when on blocks as compared with its condition when the vessel was afloat. Careful sighting showed that the vessel had sagged only $\frac{3}{4}$ inch in a length of more than 300 feet when dry docked. In all these cases the buckling was in excess of what one might expect from so small a change of form in the length of vessel between the sights.

It will be evident, then, whatever may be the straining tendencies at any time on the materials at the level of the upper deck of a vessel, those at a shelter deck will be seen still more in evidence, and this will be particularly the case if the materials in the shelter deck and its side plating are inadequate for the work they have to do.

The same remark applies to a bridge deck or any other long erection.

Now, in dealing with this question one desires to do so without any wasteful use of materials. One would prefer to transfer rather than to add when considering the scantlings. Of course, if a bridge or shelter deck be placed upon the upper deck of a vessel it is inevitable that the total weight of the hull will be increased thereby, but such increase is fairly balanced by the additional immersion allowed in consequence of the buoyancy afforded by the erections. Indeed, the additional immersion doubtless covers not only the weight of the erection, but that of the cargo carried beneath it. If the erection be of a substantial character the depth of the effective girder is increased, and consequently the intensity of stress on the upper deck sheerstrake, stringer, deck-plating, etc., will not be increased concurrently with the extra displacement.

Materials which would otherwise be necessary at the level of the upper deck may now, in part, be advantageously transferred to the level of the shelter deck or to the level of a long bridge throughout the

portion of the vessel's length which that erection covers; only that in the case of a long bridge it is further necessary to double the upper deck sheerstrake at the ends of the bridge to prevent the weakness of discontinuity at those places.

In large steamers of considerable proportions of length to depth, which ordinarily would have the upper deck sheerstrake doubled for three-fourths length, it is preferable to fit that doubling only from about 10 feet within bridge at each end to the three-fourths length, and to transfer the materials in the remainder of the doubling to the bridge side plating. A similar course is desirable in regard to the additions for proportions in the stringer plate and the strake below sheerstrake.

Where shelter decks or awning decks are fitted the whole of the additions made to normal scantlings on account of proportions should similarly be transferred to the shelter and awning decks.

It might perhaps be urged that as a shelter or an awning deck is really the top member of the girder, it would be proper to increase the scantlings of shelter deck plating, stringer, and sheerstrake to what are ordinarily adopted at the upper deck, and to correspondingly diminish the latter. Such a course is commonly adopted at spar decks, but in that type of vessel all the frames and a half of the reverse frames are extended to the spar deck, and consequently the plating of side is sufficiently stiffened and supported to enable it to develop its full efficiency.

To correspondingly increase the framing at a shelter deck would be to make the latter no longer what its name implies. It would, in fact, be equivalent to giving the vessel, say, 8 feet greater moulded depth on the same length, and consequently be an entirely different design. The vessel would certainly be stronger, but probably not so well adapted for her owner's requirements. To extend reverse frames to the height of a bridge deck would also be utterly out of the question.

Hence there is a limit beyond which materials cannot be properly transferred from an upper to a shelter or bridge deck.

Indeed, in any case wherein such transference is made it is most important that partial bulkheads, or web frames, should be fitted at convenient intervals between the two decks in order to enable the comparatively thick plating in the upper works to develop its full structural value.

Plates XVIII., XIX., and XX. show specific cases of the kind which have been alluded to in the paper.

Fig. 1 (Plate XVIII.) shows a long bridge standing on a spar deck. The vessel is of large size, and of large proportions of length to depth. Ordinarily she would require a doubling to main deck sheerstrake for three-quarter length and a doubling to the strake below for half-length, besides a doubling to upper deck stringer for three-fifths length. The bridge side plating would be $\frac{8}{20}$ inch thick.

The principal scantlings have, however, been transferred from the main deck to the spar deck ; and beyond that a further transference has been effected by using the material in the doubling to the strake below sheerstrake, a portion of doubling to sheerstrake, and the doubling to deck stringer, in thickening the bridge side plating, the spar deck stringer and bridge stringer, besides fitting a $\frac{6}{20}$ inch steel deck on the bridge. The spar deck stringer is less in thickness within the bridge than it is outside, and the breadth of 24 inches, to which the spar deck sheerstrake doubling is reduced within the bridge, is retained chiefly as compensation for the extra large side lights which, as will be seen, are very numerous in this passenger steamer. The general principle underlying the distribution of material is obvious.

The thick plates at ends of lower strake of bridge side-plating are fitted in order to efficiently transfer to the bridge sides the resistance to longitudinal stresses offered by the heavy spar deck sheer-strakes.

Fig. 2 (Plate XIX.) shows the upper works of a shelter deck steamer, and two sectional views are drawn, one of which indicates the distribution of materials which would have been adopted had the erection been a short bridge house, and the other shows the actual scantlings in the vessel. It is not necessary to refer to these in detail, but a glance at the plans shows the general principle underlying the transference of materials from the upper deck to the shelter deck in this case. The result has been the production of a substantial erection fitted to resist such considerable stresses as might be likely to come upon it when the vessel is laden.

Fig. 3 (Plate XVIII.) shows a case which differs from that represented in Fig. 2, inasmuch as it is formed of several unconnected structures, including a poop, forecastle, and a long bridge. The last-named covers about a half the vessel's length amidships, and consequently it has been stiffened up by the transference of materials from the upper deck to the extent indicated upon the plan.

In each of these cases the primary purpose of the erection is to protect cattle berthed on the upper deck.

Now, simply as a covering for cattle, and to stand the knocking about experienced at sea, the materials, if of steel, need not have been very stout. To afford an equivalent, only, to the ordinary wood coverings fitted on cattle steamers would have required but a very flimsy erection, and even a permanent cover would not have demanded thick scantlings if regarded only as a cover. But when incorporated into the vessel, and made an integral part of the floating structure, the case is altered. Unless one is prepared to see it continually being buckled and torn; unless one desires to be everlastingly caulking it and trying to keep the water out; and unless one is content to carry about a perpetual source of trouble for which no underwriter would assume a risk why one must, as an alternative, make it substantial.

Another matter which, in most cases, is associated with this type of steamer demands attention. Being intended for carrying cattle, it necessarily follows that gangway doors have to be provided for getting these animals on board and ashore. Such doors must necessarily be of large size, and to cut such openings in upper works specially strengthened as these are is a very serious matter.

It is a great pity it should have to be done, but if the exigencies of a vessel's employment demand it, why the naval architect has to bow submissively, and find some way of maintaining the continuity of structural strength at these gaps.

The plans exhibited show such openings and the compensation which experience shows to be sufficient to prevent tearing of the side plating thereat. The subject of "The Stresses at the Discontinuities in a Ship's Structure" is mathematically dealt with in a very able paper read at the last spring session of the Institution of Naval Architects by Mr. J. Bruhn, one of the writer's London colleagues, to which attention is invited.

Mr. Bruhn shows in that paper the directions taken by the lines of stresses when they approach an opening of this character, and he further shows the most simple and efficient means of succouring the structures so as to resist rupture at these places. The means which mathematical investigations would suggest are precisely those which are commonly adopted. The stresses to be resisted when in a seaway are alternately tensile and compressive, and of these the tensile, which are the most important, are at a maximum on the upper edge of the shelter deck or bridge sheerstrake. It is therefore essential that the first tendency to rupture should be stoutly resisted, because until rupture commences it cannot proceed.

Upon that account the doubling plate fitted above the doors should extend to the top of the sheerstrake, and if any cope iron mouldings are riveted to it, on no account should they be butted at or near the gangway doors. For the same reason the butts of the gunwale angle bars should be kept clear of these places. This may appear to be a trivial precaution, but it is not, for within the past year several cases of rupture in the upper works have come under the writer's notice, originating at the butts of solid half-round mouldings, and in one case the rupture extended through a plate and its doubling.

It need scarcely be said that it is a most important matter in shipbuilding to avoid anything equivalent to a notch or a sudden break in the continuity of the uppermost strake, especially within the midship half-length of the vessel where the principal stresses are greatest.

It is equally important to form gangway or cargo doors with bold rounded corners, the tendency to tearing being so much greater at a sharp corner or sudden break of continuity than elsewhere.

More than this is, however, needed. It is not sufficient to stop doublings immediately at a line with the top or bottom of a large opening in a vessel's topsides. The doubling should preferably extend beyond, so as to protect even a round corner and prevent any incipient tendency to tearing. (See Fig. 4, Plate XX.)

It is sometimes urged that no tearing will take place at the corners of these openings unless it commences at the upper edge of the sheerstrake.

Such is, however, not found by experience to be the case, and this is doubtless due to the fact that the rolling and pitching movements of a vessel cause very complex stresses to come upon her, and the least tendency of the side plating to buckle at the sides of a door when under compressive stresses might be accompanied by a tendency to tear at a corner of the door, where the slight buckling occurs.

Hence, for this reason, it is found desirable to fit specially strong frames at the sides of these openings, either in the form of partial bulkheads or bulbs, in order to check the tendency to buckling that might otherwise be set up.

Fig. 4 (Plate XX.) shows the compensation fitted at the top, bottom and sides of large doors for the purposes already indicated.

It is perhaps unnecessary for anyone nowadays to offer a word as an excuse for fitting outside doublings in the way of large openings in a vessel's sides. Probably no one now thinks them ugly any more than they would so describe lapped butts or outside butt straps. On the

contrary, to many they afford an assurance of strength and a conviction that the builder of the vessel had fairly faced the necessities of the case. They create a feeling of additional security in the minds of those who go on board a vessel bearing such traces of thoroughness on her sides, and it is doubtful whether anything in a steamer can be considered ugly which is essential to her efficiency.

The writer desires to now draw attention to the riveting suitable to the various portions of the upper works. And in so doing it will at once occur to one that whatever description of riveting is necessary at the upper deck of a flush deck vessel, is equally as much needed in way of the shelter deck when strengthened sufficiently to do the work which is offered to it. Hence double butt straps are required to the shelter deck sheer-strake and stringer, and double riveting to the laps of the side plating in large vessels of this type.

In long bridge houses, and indeed in any such erection entirely covering the engine and boiler spaces, since the maximum bending moments operate at about the middle of the bridge, it consequently follows that the butts in the bridge sheerstrake should be additionally strapped for at least the middle half of its length.

Similarly, as the shearing stresses operating on the bridge side are at about *nil* at amidships, and at a maximum towards the ends of the bridge, it also follows that double riveted landings are not required except at the bridge extremities.

In bringing these remarks to a close, the writer desires to say how pleased he is to be able to testify to the careful manner in which the principles which he has brought before the Institution are being generally recognised in the work carried out on the Tyne. Indeed, some of the illustrations on the wall are taken from actual cases built on that river

It is not supposed that anything contained in this paper will be new to the members of this Institution, but it is thought that being put upon record in this way the opinions stated may lead to a profitable discussion.

DISCUSSION.

Mr. Archibald Hogg, in opening the discussion, said, since he read his paper, last session, on the strength of steamers, this was the first time the subject, or rather part of it, had been brought before the members, and he thanked Mr. Thearle for doing so, and showing what was being done to strengthen the erections of large steamers.

Mr. Thearle's paper referred primarily to large steamers, probably very large ones, but if the principal of transferring material from the upper deck to the erection deck was right for large steamers, it must also be right for smaller ones, hence there was room for some attention in this direction in all sizes of steamers. Mr. Thearle said, "it was not considered that such a short erection as this (*i.e.*, a short bridge) could contribute much toward the strength of the floating structure, and hence no attempt in that direction was made." And now he spoke of transferring material from the upper to the erection deck. That was going in the right direction, but, while it improved the strength inway of the bridge erection, it did not increase the strength of the ship as a whole and thereby strengthen it for the extra draught gained by fitting the erections, including the poop and forecastle. The mere transferring of doublings was not a sufficient remedy. The general scantlings of the hull proper should require strengthening when these erections were fitted more or less according to the extent of draught gained, else the scantlings for a steamer without erections were excessive. A steamer with no erections was supposed to have scantlings just sufficiently strong for a certain load draught. This draught was increased when erections were built on top of the upper deck, but there was no restriction as to the position of the erections, they might be mostly at the ends of the steamer, with a short bridge, the fore end of which might be at or near midships. Such erections could not be made to "increase" the strength of the ship. Now, although the ship had greater draught and had the erections to carry, the scantlings of the hull proper were practically the same as before for the shallower draft, and especially so at a point say 10 feet forward of the bridge. That was equivalent to a reduction of scantlings: the extent of reduction would be shown if they tried to find what extra depth of hull was required in order to get the extra draught, if no erections were fitted. The extra depth would put the vessel into higher grades and thus increase the scantling, possibly all round, while at the same time the depth of the ship as a girder was increased. It was only when the erection was complete and became an awning deck that the numerals were increased, thus increasing the strength of the hull proper. When shorter erections were fitted these should be proportionately strengthened.

As to the scantlings in way of the bridge, all the longitudinal material from the keel to the bridge deck need only be such that the stress per square inch at the bridge deck be the same as that at the upper deck at a point clear of the erection.

Mr. Thearle said that to extend reverse bars to the bridge deck would be utterly out of the question. He also said a little further on that it was important that partial bulkheads or webs should be fitted. Why are the latter important? and why did he object to the reverse bars instead, that being the usual method of stiffening the shell? Lloyds seem to have a preference for partial bulkheads, as they found in the rules that "where efficient partial bulkheads were fitted (on bridge sides) the alternate frames only need extend to the height of the bridge deck." In his opinion, the bridge erection would be more uniformly stiffened and connected to the hull if the main frames and reverse bars were carried up.

Referring to Fig. 1 (Plate XVIII.), the ending of the bridge deck and side plating seemed too abrupt. The first was stopped suddenly, and the side plating only was extended in broken steps and the edge left bare. The stresses on the bridge plating would be better transmitted if the line of the side plating were tapered down to the upper deck in a straight line from the bridge deck to a point, say, about 16 feet from the bridge bulkhead, and the bridge deck stringer, increased in thickness and properly supported and stiffened, was also carried down on the edge of this plating, turned at the foot along the upper deck sheer strake and properly connected thereto; more or less stiffening, according to the size of the steamer.

Referring to Fig. 2 (Plate XIX.), they had what looked like a transferring of material downwards from the upper deck. He would like Mr. Thearle to say what compensation was made to the longitudinal strength for lowering the middle deck stringer and deck plating about 2 feet, making the 'tween deck height about 10 feet instead of the usual 8 feet limit. A somewhat similar but more pronounced case of lowering deck plating was that of a three-deck or spar deck steamer, which required by rule only one steel deck. According to the rules this deck plating may be placed on the middle deck, while the upper could be of wood. This was very convenient when the upper deck was specified to be of wood, but did not seem to agree with the principle of transferring material from the upper deck to the erection deck.

Referring to Fig. 3 (Plate XVIII.), in the way of the upper bridge deck, Was the total longitudinal material such that the stress on the upper bridge deck was not above the limit?

The bridge deck, even of a short bridge, being 7 feet 6 inches high above the upper deck, or say about 6 feet further away from the neutral axis of the girder, was liable to greater stress than the upper

deck, so that, even when there was no extra draught, the total longitudinal material should be so arranged that no material was strained above the limit, and when extra draught was allowed, the strength on way of the bridge and beyond should be made to suit.

These were all the remarks he had to make, and he again thanked Mr. Thearle for renewing this subject.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

FIFTH GENERAL MEETING OF THE SESSION, HELD IN WEST HARTLEPOOL, ON SATURDAY, FEBRUARY 24TH, 1900.

VISIT TO THE MIDDLETON SHIPBUILDING YARD.

By the kind invitation of Messrs. Furness, Withy, & Co., Limited, the members visited the Middleton Shipbuilding Yard, West Hartlepool, on Saturday afternoon, February 24th, 1900. There was a large gathering of members, who, headed by the president (Sir B. C. Browne), were conducted through the Shipyard by Mr. Henry Withy, Mr. R. W. Vick, Mr. G. W. Sivewright, and other officials.

DESCRIPTION OF SHIPBUILDING YARD.

This shipyard, though not one of the most extensive on the North-East Coast, is fully equipped with the largest and most modern type of shipyard machinery, and with the exception of certain machines specially adapted for working by hydraulic pressure, the whole of the machinery in the joiner, fitting, and other shops is driven by electricity.

A leading feature in the shipbuilding yard is the extensive use made of travelling cranes, which have specially designed jibs. There are eight, varying in lifting power from 2 tons to 7½ tons each. These cranes are utilised in the interior of the vessels building and on the upper decks for placing material *in situ*. In addition to ordinary shipbuilding operations, the firm manufacture steam winches and hand-steering gears, and have an extensive and well-equipped fitting shop for the purpose. Ship repairing is also extensively carried on, and in connection with this department the graving dock is noteworthy. It is 370 feet in length 48 feet wide, and will take in vessels of from 17 feet to 18 feet draught of water.

The arrangements for fitting out vessels are most complete, comprising two deep-water quays 600 feet long, equipped with a 70 ton mammoth crane, 50 feet high, 40 feet radius, and masting sheers. The establishment is lighted throughout with the electric light, and the electric installation includes portable electric drills and saws, and the driving of the hydraulic pumps.

The electric power house attracted special attention. A triple expansion surface-condensing engine, by Sir Christopher Furness, Westgarth & Company, Limited, working with steam of 160 lbs. per square inch pressure, provided by two boilers of the ordinary marine type, and indicating 350 horse-power at 150 revolutions per minute, drives the two main dynamos, which are capable of providing sufficient power for the various machines. These dynamos are of the drum-wound continuous current type, running in parallel, and are each capable of generating 150 horse-power at 450 revolutions, while the voltage is 120. There is also a separate plant consisting of a compound surface-condensing engine working with steam of 125 lbs. per square inch pressure and indicating 140 horse-power, which drives a dynamo utilised for either lighting or power purposes. The three dynamos, which are belt driven, the belts being of the leather link type, are all connected up to one switch board. For the distribution of power there are 29 motors, ranging from 3½ horse-power to 59 horse-power.

At the time of the visit the following ships were in process of building and completion, all of which were intended for deadweight and general cargo :—

Two 400 feet by 52 feet by 32 feet 1½ inches.
One 370 feet by 51 feet by 30 feet 10½ inches.
One 340 feet by 47 feet by 29 feet 10 inches.
Two 353 feet 4 inches by 50 feet 3 inches by 30 feet 11 inches.
One 436 feet by 53 feet by 32 feet 8 inches.

After visiting the shipyard, the members, numbering about 150, were entertained to tea by the firm, at the Royal Hotel, West Hartlepool. Mr. Henry Withy presided.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899–1900.

PROCEEDINGS.

FIFTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE THEATRE, TECHNICAL COLLEGE, WEST HARTLEPOOL, ON SATURDAY EVENING, FEBRUARY 24TH, 1900.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Newcastle-upon-Tyne, on February 2nd, 1900, which were approved by the members present and signed by the President.

The ballot for new members having been taken, the President appointed Messrs. W. C. Borrowman and G. W. Sivewright to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Eyres, Reginald J., Consulting Engineer, 8, Murton Street, Sunderland.
France, Alfred Brown, Engineer, 12, Bright Street, Middlesbrough.
Hunter, Joseph Gilbert, Surveyor, 29, Regent Quay, Aberdeen.

ASSOCIATE.

Lord, W. R., Master Mariner, 41, Queen's Road, Jesmond, Newcastle-upon-Tyne.

GRADUATES.

Berriman, A. E., Engineer, 12, Roxburgh Place, Heaton, Newcastle-upon-Tyne.
Melville, James, Engineer, Duke Street, Barrow-in-Furness.
Wraith, Herbert O., Electrical Draughtsman, 20, Granville Street, Gateshead-on-Tyne.

The PRESIDENT, in opening the proceedings, said he had a pleasant duty to perform first of all, namely to propose a hearty vote of thanks to Messrs. Furness, Withy, & Co., for their kind hospitality that afternoon. They had shown them their works, and treated them most hospitably and kindly, and he felt that their most hearty thanks were due to the firm. He must say in one way the Hartlepools set an example to the North of England. When the Hartlepools members came to Newcastle they were not shown the works, nor were they entertained.

but when the general body of members came to the Hartlepools they were always received in the heartiest and kindest manner. He always looked back upon the Hartlepools meeting with pleasure. Mr. Withy's firm was carrying on the good traditions of the place most worthily. He was sure he only expressed their united wish in proposing a hearty vote of thanks to Mr. Withy for the kind way in which they had been received, and would ask their zealous friend Mr. Fothergill to second the proposition.

Mr. J. R. FOTHERGILL (Vice-President) said it was a great pleasure to him to be asked to second the vote of thanks so ably proposed by the President. It gave him the opportunity of personally expressing his thanks to Messrs. Furness, Withy, & Co., Limited, for having thrown open their works on this occasion. He also had pleasure in saying he had never approached any firm in this district but he had found them always ready and willing to throw open their gates that members might have the pleasure of seeing their works and acquainting themselves with what was being done. That certainly showed a more enlightened age, broader views, and a great improvement compared with the days not many years ago, when it was almost impossible for an outsider to be admitted beyond the gates of any firm. He had great pleasure in seconding the resolution.

Mr. H. WITHY said he was sure it had been a source of satisfaction to them to see such a large meeting, and to have the visit to their yard. They did not see them often, but hoped it would not be long before the Institution came again. He thanked them for their appreciation.

The PRESIDENT said he would like to express how much they were indebted to Mr. Fothergill for all the trouble he had taken in connection with this meeting. He was the most regular attender at Council Meetings, and as for their meetings at West Hartlepool, his kind services were simply invaluable. He was sure they would wish to thank him for what he had done on the present occasion.

Mr. ROBT. THOMPSON was very pleased to second the vote of thanks. He could bear testimony to the good time they always had during his presidency, at the meetings in the Hartlepools. The papers had always been intelligently discussed, without any feeling of fear, there being perfect openness in all the remarks made, and considerable value added to the proceedings of the Institution. Mr. Fothergill had, indeed worked hard

for it. It had always been a pleasure to him to come to the Hartlepools meeting, and that day he felt that he must come again. He was glad to be there, and to thank Mr. Fothergill for his earnest and loyal services to the Institution.

The votes were accorded by acclamation.

Mr. J. R. FOTHERGILL said he deeply appreciated the kind words said by the President and Mr. Thompson, and he thanked the meeting for the way in which they had received them. He was afraid they gave him credit for a great deal more than he deserved credit for. As he said before, any firm that he approached readily and willingly responded to his request to throw open their works. So it was in this instance. He felt such visits offered social opportunities by which members met and got thoroughly into touch with one another. Then there was the advantage of being able to see and compare what different firms were doing, and he felt sure they would agree with him that what they saw in this district would well compare with any other district, and that we were well up to date in all modern appliances. He had also to confess there was a third reason which had some weight with him, for he found such visits were conducive to good meetings, and he did feel when gentlemen gave the time and consideration they did to the writing of valuable papers it was most discouraging and disheartening to have to read such papers before a small meeting. He was, therefore, exceedingly pleased to have heard the expression that the Hartlepools meetings were a success and enjoyable. He might add, in conclusion, that although he was deeply interested in the Institution, and was always ready to do what he could to promote the welfare of the Institution, yet he fully recognised that whatever he was able to do was due to the strong and influential position the Institution had attained, and which he hoped it would always maintain.

The Discussion on Mr. S. J. P. THEARLE'S paper on "The Distribution of Materials in the Upper Works of Large Steamers," was resumed and adjourned.

Mr. W. C. BORROWMAN read a paper on "Some Considerations affecting the Training of Young Engineers."

A discussion followed, which was adjourned.

DISCUSSION ON MR. S. J. P. THEARLE'S PAPER ON "THE DISTRIBUTION OF MATERIALS IN THE UPPER WORKS OF LARGE STEAMERS."

The Secretary read the following communication from Mr. Archibald Denny, Dumbarton :—

DUMBARTON, *Feb.* 22, 1900.

DEAR MR. DUCKITT,

Lloyd's Registry is a conservative body, and does not rapidly advance with the times, and while we on the Clyde always recognised Mr. Thearle as a man of independent judgment, still as a faithful servant of his Society, it is perhaps inevitable that he should be somewhat affected by its traditions. His paper, I think, expresses this feeling, as he is not whole hearted in the way he attacks the problem of vessels with complete superstructures. The ocean will pay no attention to what name you choose to attach to this deck, it will bring the greatest strain to bear upon the upper member of the vessel whatever it is called.

I disagree with the seventh paragraph of his paper, page 90, in which he summarises his conclusions on this head. I think it is quite proper to urge that as the shelter or awning deck is really the top member of the girder, it is proper to make it so, and I can see no reason why "it is utterly out of the question to extend the reverse frames to the height of bridge deck" (page 93). Freeboard which gives draught is the ruling factor in these matters. The two limits of the freeboard are: First, a flush deck vessel; and second, an awning deck vessel, or, as it is known by the Society with which I am more intimately connected, a complete superstructure. If an owner contracts for a vessel of certain depth to the weather deck, which is without further erection, and which in this case is a shelter or awning deck, and if he does not desire to have any greater draught than would be given by the freeboard pertaining to the awning deck, then there is no reason why there should not be a complete redistribution of the material, remove the heavy material at the usual upper deck level, in the sheer strake, stringer, doublings, etc., thicken the sides, upper edge and deck of the shelter deck; carry all the frames, and wide spaced reverse frames to this deck, then with much less material than is required by the old-fashioned inefficient method of

building a structure of the band-box type on top of the heavy material at the upper deck, you will have a vessel suitable for the work, and a weather deck which will stand all the strains that come upon it. If the owner, however, desires a deeper draught than this, then the scantlings should be increased, to meet the increased bending moment so as to give an equal stress per square inch of material, as obtained by the M.I. calculations, on the weather deck, until the limit of draught possible of the vessel would be a full scantling vessel to the weather deck. This appears to me to be a broad ground to go upon. If this shelter deck is made discontinuous by large openings, then the upper deck should be made the strength deck, unless any part of this shelter deck is of great length, then it should be dealt with as described by Mr. Thearle in the previous paragraph.

Assuming his views to be properly expressed in this paragraph, then he is not logical in the last paragraph of page 90, where he says :—"Nor is it likely that satisfaction will again be found in an arrangement which saves such superstructures from straining and leaking by cutting them wholly across and allowing the parts to work freely among themselves, even although watertight sliding joints may be provided." This was done in a notable instance by my firm in the case of a vessel of 400 feet by 48 feet by 32 feet, built in the year 1888, and had we to repeat these vessels to-day, I would recommend the same thing to be done again. It was essential that this vessel, which was of fine form, and great power and speed, should carry as much deadweight as possible; the draught was limited, and an increase in draught had the freeboard rules then been in force, by making the bridge structure continuous, could not be made use of.

As early as 1883, in a vessel 410 feet by 45 feet by 31 feet, with a bridge 158 feet long, my firm having had unpleasant experience of similar vessels, decided that it was necessary to make such a bridge an integral part of the structure, and the top of that bridge was plated, the sheer strake of the bridge was increased gradually towards the ends, and the strength tapered down into the main sheer strake of the vessel, with the best results. Incidentally I may mention that this was the result of six months' experience in Liverpool, where I was sent by my late brother William, to study the morbid anatomy of shipbuilding, and where I had the privilege of being an honorary member of Lloyd's Liverpool staff. Neither of the vessels mentioned were built to Lloyd's rules, the first was built to Veritas, and the second to the late Liverpool

Registry, a society which was always open to consider novel suggestions by shipbuilders. At that time Lloyd's rules required the sheer strake to be doubled, if a long bridge was fitted, not beyond the bridge, which common sense would have suggested, but in way of the bridge, which was ridiculous, and from Mr. Thearle's paper, it does not appear that the rules have been altered in this respect even yet.

In the 400 feet vessel referred to, in which the bridge was cut clean across, and a sliding watertight joint made, the bridge deck was not plated, as was found necessary in the 410 feet ship. I made a voyage in the former vessel, and in heavy weather the joint at the rail opened and shut 5-16th of an inch, but the vessel has been entirely successful and is running satisfactorily at present.

There are other statements in Mr. Thearle's paper which I might criticise, but I do not wish to make my remarks lengthy.

In conclusion I do not feel that shipbuilders are much indebted to Lloyd's Register for any improvement in the design of these vessels, and that Mr. Thearle is really recording what has been done by shipbuilders and other societies controlled by technical men.

Yours faithfully,

A. DENNY.

Mr. ARCH. MCGLASHAN, being called upon, said he would much rather not have said anything on this paper, because he had not studied it sufficiently to do it justice. He gathered from a cursory reading of it that Mr. Thearle intended to place before them a summary of the developments which had taken place in the superstructures of vessels, partly due to the increased dimensions of vessels, and partly to the more varied requirements of trade. He, therefore, thought it a paper of very great interest. There was very little debatable in Mr. Thearle's statements, as far as he could gather, for he was not averse to concentrating more of the strength of ships on the upper part, in continuous stringers and top sides. It would be well known to members of that Institution that the shipbuilders of the Hartlepools were well abreast in the movement to get rid of useless material concentrated lower down in vessels and have it put to the upper part, where the strains had to be met and provided for. The development of this principle had been gradual; perhaps it had been hindered by the conservative character of the rules to which reference had been made.

It was well enough known to practical men that if they wanted to

break a rod or bar, and they made a cut or notch in the surface of it where it was to be broken, the operation was made much easier, and it was very much the same with a ship. In some trades they required for facilitating loading and discharging to have openings cut in the upper works of ships. These openings were like the cutting of the surface of the bar which made it easier to break. He (Mr. McGlashan) thought the arrangement set forth in the paper, so far, overcame the weaknesses caused by these openings in a manner quite reasonable and up to date. He believed, however, it would economise material if, as Mr. Denny's communication put it, the upper portions of vessels were treated more as the top of a girder, having more material concentrated there, and taking it away from other parts where it was not so effective. With regard to the illustrations, coming as they did from a representative of Lloyd's Register, the arrangement of the butts in relation to the large ports shown in Fig. 1, Plate XVIII., could not be considered satisfactory. In fact, one would think it was intended to further weaken the structure by placing the butts in the worst possible position.

He thought the paper of considerable value, and although the writer did not claim to put forward anything new, still it was a suggestive paper, and one that shipowners might familiarise themselves with, and so avoid doing anything to weaken the upper parts of their vessels. Of course, the requirements of commerce were many and varied, and it was not so much their business to dictate to the shipowners what they should have as to give them what they required, and make up for any inequalities which might arise in carrying out their requirements. He had much pleasure in saying that this paper was valuable, and its contents should be studied and kept in view when arranging necessary openings in the top sides of such vessels as had been referred to.

Mr. G. W. Sivewright, in referring to the paper and sketches, did not agree that it was a record of the best design of this type of vessel, and considered many of the details could be improved upon. For instance, he found it was very much better to carry the reverse bars up (in the shape of bulb angle or zed framing) to the top of the erections, whether shade decks, bridges, poops or forecastles. If these erections were backed up by strong plating, little or no trouble was experienced due to local straining, although large openings were cut in topsides for gangways, etc.; but the idea of endeavouring to make up topside strength by lighter methods with the substituting of partial bulkheads was

altogether wrong, as these partial bulkheads localized the strains, causing considerable damage. The ends of the bridge plating, too, want treating in a different manner; the abrupt termination shown would be certain to cause trouble. It was a very good plan to continue the bridge gunwale bar down the outside edge of curved plating and connect to the sheer strake.

The paper, for reference, would be useful for members, and his only regret was that there was not more matter in the paper for discussion.

The discussion was adjourned.

SOME CONSIDERATIONS AFFECTING THE TRAINING OF YOUNG ENGINEERS.

By W. C. BORROWMAN, Wh. Sch.

[Read before the Institution in West Hartlepool on Feb. 24th, 1900.]

The material success of a country is so inseparably allied to its manufactures that ordinary business shrewdness has always suggested as necessary complete and adequate facilities for the training of young tradesmen. As early as the fourteenth century, there were instituted guilds and corporations for the purpose of protecting skilled labour, and for maintaining certain exclusive privileges, the violation of which, it was thought, would be detrimental to the public at large. These guilds were not merely confined to the trades of the time, but the learned professions as well were formed into self-governing bodies for the purpose of exclusively protecting their respective arts, and, as in the course of time these professions and trades multiplied, the teachers and taught combined to form corporations or universities, the teachers being the masters, the learners the apprentices. And in these mediæval days it was no doubt as common to speak of the universities of carpenters and blacksmiths, as it is now to speak of the Universities of Oxford and Cambridge.

There is no doubt that this system of apprenticeship, as instituted by these old guilds, was one of the chief reasons why we maintained so long the first place in manufacturing industries. Localities, as well as individuals, were noted for the excellence of their peculiar manufactures; and even when, in some trades, the apprentice system died out, the beneficial influence was still experienced in those where it continued to be insisted upon. The pity is that along with the special training of the apprentice in handicraft there was not incorporated with it some system of technical education. The importance of the development of this technical side of education has now become fully recognised, and by none more so than by our leading political economists, who see in its progress the essential basis of the future industrial, as well as social, advancement of the nation; they see that if besides his cunning hands a man has a well-stored mind and is technically educated, his value rises,

and he becomes of a stock of educated artisans upon whom depends, in great measure, the country's prosperity.

In engineering, all this has been especially true, as it is not too much to say that the commercial prosperity of our country has been largely, if not entirely, created by its engineers; and if the prominence to which we have already risen as a nation in industrial arts is to be maintained in the future, we must not fail to produce that material out of which good engineers are made.

It is not only by pointing to the somewhat low standard of our material success that we can show that hitherto this has been possible, but proof is not wanting if we also consider the higher standard of the progress of engineering science.

So much has recently been written of industrial progress and competition in other countries and of how other nations are gradually overtaking, if not actually passing, us in the industrial race, that our attention might not unprofitably be directed for a short time to-night to some of the educational requirements of our apprentices and young tradesmen, and to some of the means of meeting them. It is impossible, and therefore not attempted, to lay down any hard and fast rule for guidance in such matters, but some thoughts are offered for the purpose of exciting criticism, and any fallacies they may contain, it is hoped, will not go uncontradicted.

It is now fully admitted that the training of an apprentice engineer should be twofold, and that careful instruction in principles as well as experience in practice should be included in it. This admission is so general that there is no need for enlarging upon it now. But where diversity of opinion does still exist is in what is the best method of dividing the time between the classes of the technical college and the departments of the workshops. Ignorance of the conditions awaiting him in the future and an almost entire want of knowledge of his own mental powers are frequently the causes of much misdirected effort on the part of a lad in his early efforts towards his education, and this is especially so when he leaves school to commence that training by means of which he is to make his living in the future. He fancies engineering as a profession, or perhaps well-meaning parents, whose knowledge of his mental powers is even less than his own, fancy it for him, and very soon they find themselves facing the important questions whether he should commence by acquiring practical knowledge and manual dexterity in some engineering workshop or go through some

accepted course of study in the classes and laboratories of a technical college. The time at his disposal as an apprentice is far too short to permit of him learning anything but a mere fractional part of what has to be acquired in any department of his professional knowledge, and hence he is still young in his professional career when he finds occasion for regret that he did not give more time and attention to that particular branch with which he is at the moment more concerned. His opinions of the relative values of theoretical and practical training oscillate from one side to another as certain technical questions arise. Now he realises that had he been better informed in the principles of his business, had he possessed a greater knowledge of physics and mathematics, his success would have been certain; again he assures himself that his want of a wider practical experience is going to involve him in professional ruin; and this goes on until experience has furnished for him materials for proper judgment.

It is to be feared that so long as our present system of apprenticeship continues to be the rule these conflicting claims of theory and practice will never cease. Engineers, unfortunately, are still divided into two great sections, each of which looks with jealous, if not with contemptuous, eye on the other, and, to the young engineer, before whom these claims are often too urgently forced, it is the cause of much embarrassment, and, as a consequence, distrust, if not contempt, is impressed upon his mind, causing him inevitably to neglect either the one or the other rival interest, according to the influence under which his ideas have been formed. The question whether theory or practice should come first, or whether they should be taken simultaneously, or even as complementary to general education, is a problem exceedingly difficult of solution, if soluble at all. One thing is certain, the old methods by means of which young engineers were trained in their profession and so equipped for a practical life are altogether unsuitable now.

The demands of industry and commerce, the keen international competition that now exists, have entirely revolutionised the old conditions of things, and it is becoming more and more evident that, instead of the old all-round handy man, everyone now employed in engineering and other manufacturing establishments should possess some special knowledge of, and be thoroughly versed in, the requirements of his particular business.

What are the conditions that obtain at present in the process of an average apprenticeship? After finishing his course of elementary educa-

tion at school, a lad suddenly finds himself turned loose into one of the departments of a workshop, and is there left to learn his trade as he best can. He is perfectly innocent of the simplest workshop practice, and for a long time can be employed in the simplest capacities only; he finds that special machinery is in operation to perform special work, that the minute sub-division of labour renders it impossible to become anything but a very indifferent and specialised workman, that the chance of learning a definite craft no longer exists, that, in fact, the possibility of a real apprenticeship in the workshops is practically extinguished altogether. And so it frequently happens that, in the absence of means being taken to counteract such influences, the poor beginner, at a period when his faculties are sharpest and his mind most retentive, runs the risk of degenerating into a mere specialist, into a workman who can do one thing only and without the slightest claim to be called a mechanic, far less an engineer. In the old days an apprentice used to be taught a definite craft, and his trained hand was of the highest value in work demanding the use of hammer, chisel, and file; *then* he was trained in all the details of his trade, and, after a definite pupilage and with the object of mastering the outlying branches of it and widening his practical knowledge and experience, he became a journeyman before finally developing into a master. *Now* he learns only a portion of his trade, because he is trained amongst men who are capable of doing little more than one thing, who are dependent upon a series of other men, or sets of other men, to either finish what they have begun or begin what they will subsequently finish. Now the introduction of exact machinery has almost banished handicraft altogether, and cheap and rapid production by minute sub-division of labour renders it impossible for a workman, unless he be of exceptional character, to so exercise his hands and mind as to develop deeper insight, broader view and capacity and brighter intelligence, and so, if he be only skilful with his hands, he becomes no better than an unskilled labourer the moment his work can be performed by means of a new machine.

On the other hand, if while young he is drafted into some technical school where the aim is to give instruction of a specialised character with the object of commencing him in the elements of his professional training, there is the danger of stinting and narrowing his mental growth, of antedating the cramping effect of a specialised calling, and, just as in the case of the specialised workman who can do only one thing well, we have a lad whose mind is trained only in one direction, who is

incapable of forming any but the simplest and most commonplace ideas, and who only fixes his attention on those features of his profession in which he finds himself most proficient, and leaves out of account altogether those other features which are none the less important and essential to his full development.

Before determining, then, which course of training should be chosen as being the best, a youth should know, or be led to know, the powers of his own mind, and the chances of a successful career he may have to his hand in the future. If he be of the material which goes to make a good engineer, it perhaps matters little which course he chooses first; his ability and bent of mind will soon become apparent, and he will probably be able to mould his career into lines at once most congenial to his tastes and in keeping with his temperament; but if he is not of such material, and if instead of being able to pick and choose his own way he is thrust into accepting whatever is offered, or, if by-and-bye he discovers he is not at congenial work at all, much of his training so far will have been of no effect, and he has to begin over again. And so, to study our subject fully and before either technical college or practical workshop is considered, we are forced a step further back still, and have to inquire—what of the ways at school? There the real preparation for the after training should be made, there a sound foundation for the after professional work should be laid and *method* should be all and in all; the method of learning how to learn. At school the mind by healthy exercise should be trained to look at questions from every point of view, and so develop general mental culture, good judgment, and ingenuity, rather than have it loaded with a detailed knowledge, and so equip it as to be able to adapt itself to any course of study it may be put to afterwards. To the engineer, as to every other business man who has frequently to decide rapidly when neither his text books nor his notes are at hand for consultation, a well-trained memory is absolutely necessary. To remember well is sometimes of as much importance as to understand well. To train the memory demands its application, and in the process the mind is stored, and if, with retentiveness of memory there be associated a correct method of reasoning, a correct habit of arranging in proper and natural sequence all the facts of a problem, it is no longer found to be an effort to remember them, and its training therefore should have every prominence in a general school course.

There has always been great diversity of opinion regarding the best methods of thus strengthening the mental powers. Until recently it was claimed that nothing whetted the intellect or strengthened the mind like

a study of the classics; that there was nothing to compare with the stern mental discipline necessary to facilitate an appreciation of the old Latin and Greek masters; and so these dead languages, Greek verbs and Latin declensions, used to be poured into the head of a youth until there was little room left for anything else, the principal ingredients of instruction continuing to be exactly the same as were given centuries before, and when England had no literature of her own. The very fact that the system of education was not essentially different from what it was several centuries before ought to have been sufficient evidence that some alteration was needed. Life, and especially educational life, is far too short to permit of any portion of it being spent in acquiring a knowledge that only *may be* useful, for, speaking generally, it may be taken as a fact, although one regrets to have to say it, that the primary object of all education, whether it be what is termed liberal or merely professional, now as in antiquity, because even in Plato's day there were the philosophers and dramatists and artists teaching liberal education, while the Sophists supplied the professional side, is not altogether to develop the mental and moral qualities of the pupil for their own sakes, but to enable him to make a respectable living, to become a useful citizen, to convert, in other words, his brains into money! And when this is said, it is not intended to contradict what has been said already, that the primary object of the school period is to acquire an orderly method of learning, and that the nature and amount of the knowledge acquired are only secondary; but are not secondary results sometimes very important and not to be disregarded altogether? Hence it is held that there is a direct advantage, both from an educational and professional point of view, with newer studies unfolding themselves before us, to so arrange the school course that it shall be potent for cultivating all the faculties of the mind and bringing them into full and healthy activity, and in which classics have only a moderate part. Living languages are surely quite as capable of polishing our brains as dead ones, and to the student of science, history, music, drawing, there would be opened up such a world of delight as the youth who has spent all his time at classics cannot even imagine. The difficulty is to determine how much attention should be given to the one and how much to the other, for it is clear that classics are not now regarded with the interest they used to have bestowed upon them, although their study will never cease, and should never cease, to form part of a liberal training. The whole purpose of the school, then, should be to so prepare boys as to render them capable of succeeding in any calling they like to choose afterwards, through the

advantage derived from a healthy, active intelligence, a habit of logical reasoning, and a stock of useful knowledge.

As success in every walk of life depends to a great extent on early training, every healthy boy in the country should be made to undergo some such elementary course as has been indicated. When this has been accomplished, the specialising of his studies, his secondary education, his technical education, if you will, may be commenced. By this time a boy will have had opportunities of developing any capacity he may possess, and the process of selection may commence. Up to this period education should be general and universal. Beyond this the training should become of a nature more special, and from the mass of youthful material there will now be sifted out the various grades of capacities, the lowest going first to be the workmen, the next the foremen, and so on through all the grades until there are those left upon whom too much time and money can hardly be spent.

It is at this stage that the difficulty already referred to, the choosing between a course of theory and one of practice, crops up. If the lad is to be something more than a workman, he must be guided in the proper selection of a course of study. Hitherto he has been chiefly absorbed in book work, in verbal studies, in which his memory and reasoning faculties alone have been exercised. His eye and his hand still require disciplining before he becomes a fit scholar for skilled labour and a practical life. Now hitherto the teaching of science in its relation to trades has been, in this country, firmly restricted, and the teaching of the practice of a trade in any technical school where Government support was given has always been forbidden. While something can perhaps be said in support of this in the case of colleges and universities, it becomes a question whether it should be so strongly objected to in institutions for secondary education. It is, of course, absolutely impossible to give any considerable useful practical information of any art in such institutions, but a workshop in such a school would be a most useful adjunct for providing certain deserving boys with the means of acquiring a little skill in a healthful and pleasant way. As was already pointed out, an ideal trade apprenticeship, where the learners, docile, obedient, and hardworking, are brought up under the fostering care of an able workman, skilled in imparting knowledge and eager to give his charge every possible opportunity of self-improvement, is purely imaginary, and, as instead, we too often have apprentices neither earnest nor studious, but boy-like, fond of variety, and consequently careless and inattentive, and often quite incapable of enduring the monotonous routine of a long

working day; and remembering the importance of permitting a boy to form some opinion as to what is, and what is not, of practical value to him, and thus allow him to pay more attention to the former, to guide him in determining which results will be of real use and which will form only exercises in applied science, and with the further benefit of saving much precious time, it is suggested that a short course in the laboratory or workshop of a technical college should be taken between the time of leaving the general education school and that of commencing his apprenticeship. There he would be shown and become acquainted with ordinary tools and materials. He would be under the charge of trained and competent tutors who would teach him their uses, and in a manner utterly impossible in the average commercial workshop.

There are always real pleasure and profit for boys to be got from working with tools and amongst models; and if at the end of a year or so in such a place he should have learned little more than to know a plane and a file when he sees them, to be able accurately and scientifically to use his foot-rule and compasses; if by this time he has been able to train his hands and eyes to work in sympathy he will have spent his time well, and be in some degree equipped to start an apprenticeship in any workshop he may be employed in. He will not thus learn his particular trade or art, but he will be helped materially to choose it, and thus pass on to its actual conditions by working at it. Such a training would also make provision for his introduction to theoretical knowledge, to sketching and drawing, and the grasping of details of construction. He will then know that an apprenticeship means far more than merely learning to chip or file. He will learn the time required to do certain work, the proper finish that certain work should have, the right and wrong way of handling such work, shop systems, the character of his fellow workmen. He will further begin to see that the development of manual without co-ordinate intellectual training forms only a small part of what will help him in the work that lies before him in the future. He will observe that the higher the standard of general intellectual culture he attains to the more solid will be the groundwork of all his after special instruction. He should, consequently, along with technical studies have some one other subject at least as a hobby. Let it be history, geography, philosophy, a foreign language—something which is outside his immediate business and not visibly related to it, something he takes to because he likes it for its own sake, because he knows that his character is enriched and strengthened by it, because it helps to give him a wider outlook upon the world of nature, of books, and of men,

and because he may thus prepare himself better for the duties of a citizen and parent as well as fill an honoured place in the ranks of industry.

It is not suggested that because a man remains a workman he should not continue his education. It has already been shown that industrial success will depend, in great measure, upon the intelligence and training of our workmen. Any man can easily learn to handle a machine, but he should also learn what principles lie behind it and those upon which it has been built so thoroughly that he could undertake to design it or alter it so that it might be adapted to perform any other similar work. A mere machine worker is no more a mechanic until he approaches his work with an intelligent knowledge of the principles of mechanism, than a moulder is a metallurgist because he simply works amongst metals. In engineering, therefore, we require evening classes, at which the technical instruction given will make better fitters and turners, more intelligent patternmakers and draughtsmen, as well as that which goes to train those men who are ultimately to manage and thus push forward these industries. To accomplish this, properly equipped establishments are necessary, where, along with technical instruction, there will be developed breadth of view and capacity in those attending them. With such education judiciously directed, and in which the teachers are careful to organise their classes so as to broaden the basis of instruction to cope with the narrowing tendencies now so common, much will be done towards minimising the extreme, and, as some say, the disastrous effects which subdivision of labour and specialisation in handicraft are causing.

But this must, of course, be done with discrimination, otherwise it ends in absurdities. It is hard to conceive, for example, what possible good could be got out of a course suggested by a speaker sometime ago, who advocated the teaching of chemistry to a house painter, because of the benefits he would gain by knowing the chemical laws operating in the making of his different colours. A more ridiculous travesty of the aim of technical education can hardly be imagined. If a painter is to be technically educated it cannot be done by means of a pernicious smattering of chemistry, a subject outside altogether the range of his business, though perhaps related to the trade of a colourmaker, but by a widening of the training of the painter in his own particular handicraft, in those things truly pertinent to the technique of his trade, and as such taught him fully and freely. It is also difficult to see what good could be derived from teaching a turner or patternmaker the operations of extracting dyes from coal tar, something he will never be called upon to

perform in his professional life. A turner's duty is to turn quickly and accurately, a patternmaker's to make his patterns so that sound and economic castings may follow; and although these cannot be taught in any technical college, something bearing directly upon them can. Any attempt to go further with a tradesman ceases to be technical education, because technical education does not depend merely on the subjects that may be taught under this name, but to as great an extent on the pupil who is being taught. Educational progress is still too frequently estimated by the number of thousands of students who are being taught in our technical schools without any consideration being given to what or how thoroughly they are being taught. Information of this sort is worse than useless, because by it alone we fail to discriminate between what is really useful and what is merely statistical. Broadly, it may be put that in crafts where the average workman has not to design, but has instead designs made out for him and to which he has to work, it is sheer waste of time and money to give him a mere superficial smattering of higher technical knowledge, or of a trade outside his own. On the other hand, a knowledge of some subjects like geometry and mechanical drawing would be of infinite advantage to him, because there can be no doubt that the mechanic who can draw quickly and accurately becomes much sooner an adept at his trade than the man who cannot do so, because the drawing down, in the first place, of a detail in machinery is the best possible introduction to the making of it afterwards, and skilful handicraft is produced much more easily when the accuracy of measurements and habits of precision have been cultivated; for does not the difference between a skilful workman and a slovenly one consist in the fact that the former carries out his work to the required exact dimensions, while his less skilful friend may either have it larger or smaller, and thereby totally unfit for its purpose. Just as very little accurate knowledge of any kind can be acquired without a knowledge of reading, writing, and arithmetic, because they are the tools with which men dig out of the mine of learning, so knowledge of the elements of mechanical drawing would prove quite as useful a tool as these three in the hands of a tradesman. At one time so important did a knowledge of mechanical drawing appear to the French Government that the Commission on Technical Education concluded that, for the working classes, technical education meant merely instruction in mechanical drawing. And they were not far wrong, because it is a key, in the use of which an intelligent and industrious workman can open for himself new ways to knowledge and for the possession of which one

need only know how to read, write, and cipher correctly. In spite of all this, however, it is a notorious fact that a large percentage of British workmen cannot either make or understand a drawing. A knowledge of drawing would give him the power of putting his own ideas on paper, while it would also enable him to interpret the ideas of others, and much better than any spoken explanation could possibly do.

It is sometimes stated that the average Englishman is behind his Continental neighbours in the appreciation of art. Whether this is so or not, it is a fact that drawing is taught less and to fewer people in our English schools than it is in almost any other country having any pretensions in the way of education. In France, Germany, Belgium, Sweden, America, and in some of our colonies, drawing is compulsory, and has many hours each week devoted to its teaching.

In saying this it is not intended to cast any slur on our workmen, because, as Dr. John Inglis said the other day in his address to the Institute of Marine Engineers, "he is not, as an individual, inferior to his predecessors who brought the steam engine to its present state of efficiency," nor does he "believe that what he calls the 'uncontaminated' British working man is excelled or even equalled by the workmen of any other nation in skill or endurance whilst he is employed at his own particular handicraft. In the departments of work demanding physical strength and a certain quantity of conscientiousness, without which no important structure or mechanical contrivance can be properly executed, he is, when at his best, the most reliable in the world."

Beside all this, however, we have to admit that even a high degree of expertness and proficiency in handicraft may frequently co-exist with an empty head, and consequent complete intellectual stagnation: so that while fully acknowledging the importance of manual skill and dexterity it must at the same time be remembered that their value is distinctly limited. They must be supplemented by other disciplined knowledge if we wish to have workmen capable and thoughtful and ready to undertake any of the duties of industrial life. Such an education would at the same time influence his character, awaken his inventive faculties, otherwise left dormant, and so develop the power of the human intellect over mere dead matter and thus fulfil the highest purposes of the engineer—the minimising and alleviating the difficulties of life.

At a time like the present, when the effects of foreign competition are being so persistently brought before us and are attracting so much general attention, it is not inappropriate to our subject to consider briefly how some foreign nations stand as regards their means of

educating their industrial classes, and the influence of such education on their manufacturing and other industries. A comparison of our methods of teaching a craft and giving technical instruction with the corresponding methods of foreign countries will show us at the outset that in so far as a practical apprenticeship served in the workshop is concerned, the failings that mark the system at home are quite as prominent, if not more so, abroad, but that as regards technical, especially primary technical education, the contrasts are more in evidence than the analogies. While our system pins its faith to a shop apprenticeship combined with a simultaneous course of study at evening classes, on the Continent and in America their systems are based on the now recognised fact that a real apprenticeship, as indicated earlier in the paper, does not now exist. Whereas we prohibit all attempts at teaching trade methods in schools, and, where anything practical is attempted, it is only secondary and subsidiary to the theoretical and scientific instruction given, they have specially organised and graded courses wherein both theory and practice are conjoined and where specialisation in study is a prominent feature.

In France the present system of primary technical instruction has now had a trial of over twenty years, and is the outcome of a movement in favour of some type of school where trade classes could be taught. After a systematic investigation had been made, those in authority found that throughout the whole country craftsmen were becoming less and less skilful with their hands, and, looking about them for a reason, had little difficulty in seeing how this state of matters arose. It was seen that the same proficiency in handicraft could not now be attained as was possible formerly, because the latest systems of shop organisation and management were tending to consider a man as being simply the intelligent part of the tools he was employed to handle. It was further recognised that the ever-increasing tendency towards the sub-division of labour was making a few years' apprenticeship far too short to enable a lad to have experience in more than a few of the departments of instruction.

The French Government acknowledging all this, and that it was too much to expect any serious step being taken by the employers of labour to institute remedies to meet such influences, founded these apprentice or trade schools. That they have been successful for France we have abundant testimony, for whereas at first an approximately small portion of time was spent in practical work, now they have more and more practical work undertaken by the student-apprentices as they graduate

through the various divisions of elementary, manual instruction, and higher grade schools.

In Germany the same system prevails, but in a more pronounced degree. Among the many causes that have tended to the phenomenal progress of German industry and commerce lately, we must acknowledge the advanced educational conditions upon which that country has placed so much faith for their development. It is recognised that, in these days of rapid intellectual progress, it is as possible for educational systems to become old-fashioned and out of date as it is for machinery and factories, and, while the facilities for affording technical instruction to workmen are perhaps not better than our own, the organised system of secondary education is as nearly perfect as it may be to meet the requirements of to-day, while those colleges whose detail and equipment are designed to afford facilities in original and independent research work in physical science are not equalled anywhere. Of course we must remember that Germany, like America, is comparatively recently in the field, and is making the best of all available sources of information. In the trade schools the instruction is essentially of a practical nature and provides a general preparation for an industrial life. They lead the way for a lad into the workshops and factories by giving him every kind of general and special knowledge, as well as habits of industry, while they, over and above this, go far to help him to choose his future calling. It has also frequently been shown that the instruction given in this way has helped to revive and develop several industries that otherwise might have died out. The grading of these schools is carefully defined, the instruction is strictly disciplinary, examinations are not too frequent, and as a consequence the study is broad and thorough. While with us technical instruction is as yet chiefly supplementary and is administered in separate courses, in Germany, as on the Continent generally, and in America, it is looked upon as of far more importance and as part of a great national educational system.

In Japan the development in every department of industry, and its effect on trade in the Far East, has come as a surprise to most people; but for several years now the Japanese have been studying the system of western nations, and are now, so far as educational matters are concerned, almost abreast of any industrial nation in the world. As showing the progress being made in technical education amongst the Japanese, it is interesting and instructive to note the curriculum laid down for the training of their engineering officials in the Imperial dockyards. There is as yet no organised system of apprenticeship or trade schools, but the

courses followed by both officials and foremen are very advanced and thorough. The same rules apply equally to all departments of the navy, such as shipbuilding, ordnance, engineering, etc., and the training is graded into first, second, and third classes. The highest class of officials, those who ultimately become chief constructors and inspectors of machinery, ordnance, and such like, come under the first class, which is as follows:—Students enter the university, after examination, at ages ranging from eighteen to twenty, and remain there for six years, the first three years of which are spent studying higher mathematics, physics in all its branches, chemistry, drawing, etc. At the end of these three years, students have to decide which particular branch they intend to follow, and during the remaining three years they study the technical subjects appertaining to this branch. They also spend the summer vacation, of about four months' duration, in acquiring practical knowledge in the workshops and building yards of the dockyards. At the end of each year they are examined as to their progress, and the results of the five previous examinations together with the final examination at the end of the sixth year, decide to a certain extent their future prospects. They thus pass into the junior, or sixth grade of constructors. The minimum time required for promotion to the fifth grade is one year; two years are required for the next step, from the fifth to the fourth grade; from the fourth to the third grade requires five years; from the third to the second grade two years. These times are the minimum, and it might take an exceptional man to pass through all the different stages in the time mentioned.

The second class consists of those fitting themselves to be sub-inspectors of work and senior foremen. They enter as ordinary workmen, at ages varying from sixteen to twenty, and during that time certain of the more intelligent ones are selected for education in the dockyard schools and colleges. The period of training extends over four years, half of each day being spent in the schools and the other half at practical work in the workshops. During the first two years the tuition in school is confined to the subjects required for general education. They then decide which branch they are going to follow, and for the remaining two years the half days spent in school are devoted to those particular technical subjects appertaining to the branches selected. Examinations are held at the end of each year, and the results of these, combined with the result obtained in the final examination at the end of the fourth year, determine their order of promotion, etc. At the end of this time they qualify as minor officials, and go through ten grades, the minimum time

for each of which takes one year, and the final grade is composed of senior foremen, sub-inspectors, etc.

The third class is composed of those selected from the ordinary workmen after they have reached the age of thirty years or so. Those selected are allowed to go to the dockyard school during the half of each day for a period of three years, during the first eighteen months of which they acquire an ordinary rudimentary education, and during the latter eighteen months they learn certain principles and general technical information regarding the branch to which they belong. These likewise are examined at the end of each year, and at the expiry of three years qualify for positions of chargemen in the various departments.

The ordinary workmen, entering at the ages ranging from sixteen to twenty, serve no apprenticeship. As they acquire the requisite skill and experience, their pay is gradually increased until they get the current wages of the district for their particular trade.

We now understand why it is that fewer foreigners are now employed in Japan than used to be formerly, and why, except in such new industries as yet require the supervision of foreign experts, the services of foreigners are being more and more dispensed with. The Japanese see that if a nation is to be great its schools must be attended to, and that neither money nor time must be grudged for the erection, equipment and maintenance of such schools and laboratories of all grades.

Instances could be multiplied to show that this same activity in matters concerning education is pervading all countries having industrial interests. Spain, Norway, Denmark, Italy, and others, are all bestirring themselves in the same direction. They see that the nation which possesses the best schools is the best prepared for the great industrial struggle which lies before us, and they are determined to keep in the front rank in all matters affecting the education of their people. They recognise that success depends, not so much, nowadays, on the possession of the raw materials of manufacture as on the scientific application of recent discoveries to the ordinary processes of manufacture.

Although it is now sixty years since a special Committee of Council was instituted in England to look into our educational system, it is just thirty years since any real activity and progress were commenced in technical instruction. Before this, although we were first among the nations in skilled labour, we were somewhat behind most of them in systems of technical education.

France, Belgium, Switzerland, and Prussia offered many advantages to young engineering students that England had not yet thought of. It was not until these countries, as well as Germany and America, began to profit by this that we took up the matter in earnest. At first it was the exception to consider engineering science as part of a collegiate course. It had not yet taken its place among the learned professions; at all events, it had not yet been recognised as such. There also existed great difficulty in securing competent men to take the place of instructors, not because there were none who had the requisite knowledge, but because there was a want of proper sympathy on the part of educational authorities. It was thought that having provided a class room and a blackboard the teacher should be able to do the rest; that having provided him with a sufficient supply of chalk, they had given all the support necessary to a chair of engineering. Luckily, in the face of such odds, good men were usually chosen to fill these appointments, men who came out of some works' department or drawing office, and with a very complete knowledge of the very things a young engineer requires to know. They had, however, to find out for themselves the best methods of teaching, whereby young students were trained in the principles of their business on the one hand, and whereby the members of the college board were educated up to a proper appreciation of the fact that very substantial aid in the prosecution of their duties was required on the other.

To-day this is all changed. The modern professor of engineering undertakes his duties as part of a recognised curriculum. His requirements and expenses in the matter of apparatus and books are known and accepted. He is no longer under the distasteful necessity of having to extort, almost by force, the requisite cash for his working expenses. He is usually a man whose theoretical knowledge has shot far beyond the usual requirements of the consulting room or drawing office, and who, after a subsequent successful career at college, and possessing certain academic tastes, has been chosen by his professor as demonstrator and assistant, and so makes his way to a professorship.

Except in a few instances he finds it impossible to make fame by means of any practical work, and to his credit it has to be acknowledged that he labours hard without the stimulating hope of making any great pecuniary gain. In research work, in the laboratory, he is at home, and has, in many instances, laid his practical brother deep in his debt; here he has chances that few manufacturing engineers ever meet, and he makes the most of them. He spares neither time nor thought, experi-

menting from which he evolves much useful information, and this he dispenses liberally. It would be difficult to estimate the amount of such information, much of which cannot be applied in its present form to our every-day requirements; but there it is, stored, until our increase in knowledge of it makes it directly useful. In such work he excels, and up to this point he is a good man, but laboratory work is distinctly limited; the moment experiments go beyond a certain dimension they are outside his province. The instruction he furnishes his pupils is most valuable, but it might be more so if he were to remember the nature of the work they will have to perform in their every-day life later, and because he is apt to view all his work through the eyes and from the platform of the professor and physicist merely. For corroboration of this, we have just to turn to the experience of one of our most successful science teachers. Professor Kennedy confesses that if he were to take up teaching now after his experience in these later years of practical work, he would do it better and more successfully than he did do it when he was a professor and nothing more, a wider experience in the field of practice, and a closer intimacy in daily life with those young engineers whom he knew only as students before, being the reasons for this change.

It is usually an easy matter to teach engineering to a batch of students whose capabilities are tested only by examinations. It is a difficult matter to keep before students the fact that so long as they are students they can learn only a fraction of their business, and that the larger portion of it must be acquired in the college of experience. It cannot but be so. In proceeding in his college course, the student must do so deliberately and by degrees; each step in his progress must be considered carefully, one at a time, if he is to study to any purpose at all. In his investigations he must know and understand every condition —and in his eyes each condition is equally important with another, and cannot be disregarded; but this very concentration of attention not infrequently throws out of all proportion other considerations quite as important. Teachers confess that this is a difficult matter, and their task is increased when, recognising all this, they strive to so arrange their curriculum that all such influences may be carefully met and counterbalanced; when, remembering that engineering cannot be taught inside the four walls of a college by lectures and text books merely, they have to work within certain prescribed limits to satisfy the demands of examinations.

No doubt such instruction has its beneficial effect on great masses of students, though it were for no other reason than that by it, and the

effect of systematic study, their knowledge in many departments, in which they were hitherto ignorant, has been extended. But such instruction is now so cheap, that to be instructed merely is not now considered to be of great importance. It is sometimes too readily assumed that because a youth has passed through a course of science teaching he is thereby fit for anything. Knight-errant like he fares him forth to do mighty deeds, for has he not all the weapons of instruction necessary, and have they not been ground and whetted every one of them by a careful and capable expert? If he is careful he should not fail, but if these same weapons be not wielded carefully and sensibly, they may upon occasion be very embarrassing, and even prove a hindrance rather than a help, and for this reason they are simply part of his whole equipment, there are other weapons against which he will be pitted, of which he has yet no knowledge. He will often wonder why public confidence is so unreservedly placed in older engineers, whose knowledge and ability he holds in little esteem. He will see their opinions accepted, while his are hardly listened to. In comparing his knowledge of subjects which he has learned, each under a special professor may be, with that of his elders, he finds that he has the advantage, and yet his capabilities are placed at such a low estimate. He forgets he has yet to learn his trade; though he may possess all the scientific training he claims to have, though he may have, by this knowledge, fitted himself to fill at some future time a position over those whom he has to serve now, he has just completed a fraction of his education, and must be careful not to puff himself up by this fraction, so that he will fail to achieve the fraction that remains; by doing so he will neither be a useful subordinate nor a pleasant colleague. He has yet to differentiate between instruction, education, and experience. The first implies merely an acquaintance of text books and lectures and is tested only by examinations, or that process of testing a man's capabilities of gorging and disgorging information, and which in itself is not enough. Education is the healthy exercise of the mind, out of which grow the best qualities of the understanding, the power to acquire and assimilate instruction and so be able to glean experience—experience or that resultant effect left on the human brain by numberless impressions, and by means of which the skilled engineer is unconsciously guided in all his determinations. It is the power of bringing before the mind's eye all the features of a problem and of criticising them, to be able to determine what are the big things and what the

little in these problems, and thus have a true sense of the proportion of all the series of operations by which his plans are to be carried out. This experience is a plant of slow growth, and the public know that, and that without it knowledge in itself is of little value. For example, an engineer cannot be said to be completely trained if he is still ignorant in the matter of costs, if he cannot tell how much money or what time will be required to perform certain work. Before he can do so he requires to have done past work and so have gained experience, and this is a matter neither taught nor learned inside a college. Public companies and corporations, before employing an engineer, generally ask —what of his past history? They are careful to adopt the precaution of scrutinising what he has already done successfully and well—for after all, he is the best engineer who gives the best engineering for the least money. His designs may not be the most striking, they may not be strictly scientific, but if they can be carried out expeditiously, economically and successfully to serve the purpose wanted, it is evidence of a healthy, intelligent experience, for practice is generally ahead of science.

These, then, are a few points that more or less have to come at some time or other under the consideration of every young engineer. There are many others which must occur to all of you. For example, no attempt has been made to specify an ideal apprenticeship to meet present circumstances, nor to suggest whether the time served in the workshops should be modified in the case of a lad who has had some technical experience before leaving school. Departmental training, such as graduating through the various shops and drawing office, has not been considered. These and others, it is hoped, will be taken up in the discussion of the paper afterwards. There are other fields of knowledge which must be explored and known before the young engineer stands fully equipped. It has been shown that technical education has much to do with the industrial and commercial prosperity of a country, but it can also be shown that it is possible to have too much technical education, and that popular scientific education may be too one-sided in being too mechanical and too technical. These other departments of knowledge that have to be explored do not depend at all on any mechanical or mathematical training, nor are they approached by any of the paths of science so much as by the guiding influence of ordinary common-sense. It is not sufficient to consider merely the means of education available for the industrial classes and the influence of such instruction on manufacturing and other industries, but it is also

necessary to ascertain the general causes and the actual results of industrial and commercial enterprise.

The subject of foreign competition has already been alluded to, and while it cannot be classed as a strictly technical subject it is none the less a matter upon which it is as well that the rising stock of engineers ought to be well informed. It has often been the excuse for spending large sums of money on technical education, while it would be a perfectly fair question to enquire whether hitherto all the money so spent has been laid out to the best advantage. Foreign competition is not a thing of to-day or yesterday, but has now been with us for some considerable time. It had really been going on before we were aware of it. We came face to face with it fifty years ago at our first International Exhibition, when we learned for the first time that other countries besides our own were progressing in manufactures and claiming a share in supplying the world with their wares. It was then seen that our supremacy in the industrial race was being challenged, and that it was necessary to keep moving.

It will be shown that other influences besides technical education have been at work to help foreign competition, because if we consider Germany and America, our two greatest industrial rivals, we shall see that while Germany, as has been pointed out, has the most perfect system of education in the world, and, it is held that her great progress has been entirely due to this fact, America, whose educational systems are not so perfect, has really to be reckoned with as a rival with far more apprehension. Again, too much importance should not be attached to the recent importation to this country and some of our colonies of large consignments of American machinery, locomotives, and bridges.

This old bogey, foreign competition, has again and again been exhumed, and we have heard urged, almost *ad nauseam*, the necessity of doing something to meet it, while the real facts were overlooked that American cheapness and quickness of delivery had in nearly every case been aided by certain local and temporary conditions that really reflected credit than otherwise on British firms. The year that closed two months ago was one of unexampled industrial activity and prosperity in every department of commerce; and if we remember that the conditions of international commerce have changed so considerably during the past few years, it should not be matter for surprise to find great development of two such nations as America and Germany. It is sometimes inferred that because these countries are earnestly bidding for part of the world's

trade England is behind in her methods and too blind to see it. We are pointed to consular reports for proof of this, and from which it might be concluded that England generally was going to the dogs. But we are not so conservative as we are sometimes said to be; and if all was known it would be found that the consular reports of every commercial country in the world were remarkable for the very complaints with which ours are so often filled. The British working man has not yet lost his cunning, nor the British trader his courage and enterprise, or how is it that so many young men from America and Germany, as well as from all parts of the world, come to study in our workshops, our warehouses, and our universities?

If a fair comparison were made it could be shown that the value of the foreign commerce of Germany when compared with that of Britain is usually very much over-estimated, and that although Germany is making enormous strides in many industries, more especially in those where superior knowledge and technical skill can be applied, we are as readily rising to meet them, and if it be true that in some instances America and Germany are able to outdo us, it is equally true that we are outdoing them in something else.

In comparing American with home engineering products they do not seem to possess the merit of being much, if any, cheaper, because machine for machine in many instances they are considerably dearer; nor does their construction seem to indicate any superior average intelligence or thoroughness in their workmen; nor, where powerful, responsible, and reliable machinery is required, can it in any way be said they excel such English products. What they do excel in is the production of small things cheaply, and so we have our markets flooded with ingenious puzzles, Waterbury watches, sewing machines, agricultural implements, and all those things that are made by the thousand, similar in design, similar in structure. If we consider huge engineering structures it will be found that there are few countries where such terrible catastrophes have occurred, due to their failure, indicating a want of knowledge in such things, and very often a total disregard for first principles. Where such structures have been successful, they have been either actual English productions or good copies of them. Whatever are the various factors that have tended to the almost phenomenal rapidity of advancement of our American competitors and of their almost daring developments of ingenuity and skill cannot be considered now, but there is no harm in reminding ourselves that partly, at all

events, they are due to the fact that in America the people, to whose ingenuity such strides have been possible, are essentially English; and given a good parent, can any one doubt the possibility, when circumstances of environment and such like are suitable, of the children sometimes going one better, more especially when the parent stays at home and sends other children out to civilize and colonize the world.

DISCUSSION.

Mr. Tom Westgarth said he did not speak first because he had much to say, but because he had an idea rather contrary to that expressed by Mr. Borrowman, and so thought it well to state it at the beginning. He thought that technical education was a good thing, but he thought that no man should go to a technical school to learn his own trade. That might seem at first sight, absurd, but perhaps they would agree with him presently. He was sure they must agree that nobody could be taught in a technical school his own trade as well as in the average workshop. On the other hand, how many people would be far more capable of conducting their own trade if they had some technical knowledge of other trades which bore thereupon? He had had apprentices come to him who had been at technical schools and science colleges, and he was sorry to say nine out of ten were not well trained, though they thought they had a deal of knowledge; but they had to teach them their trade. If a youth were going to learn engineering, some knowledge of chemistry would be useful and also pleasant to learn. He agreed with Borrowman that a boy should have some hobby, and have some knowledge not bearing upon his own trade that would be interesting, useful, and amusing to him. Supposing shipbuilders had some technical knowledge of engineering, they would not make such peculiar structures as they sometimes saw thrust into an engine-room in the way of engineering, and if engineers had some technical knowledge of shipbuilding they might be saved from raising questions which no doubt some times seemed foolish to shipbuilders. If an export cotton or linen merchant had gone through the technique as to spinning, weaving, and dyeing, how much better he would be able to deal with his own particular trade; but if they sent a shipbuilder or a merchant to a technical school to learn the details of his own business, he would learn little and he would learn infinitely better in his own business when there. To go back to engineering apprentices: A boy learned by far the best and by far the most by assimilation. He acquired a knowledge of what things

should and what should not be, by being always amongst them. But Mr. Borrowman hinted, he thought, that boys were generally pitchforked into shops and no trouble taken to teach them. He did not see how they could teach them. They had to pick it up and be educated by association. No amount of technical education could teach a boy that kind of knowledge. He wished to qualify his remarks and say that he looked upon technical education and the training of a science college as totally different things. He thought every young engineer and shipbuilder, and every young man in similar branches of trade, should go to a science college if possible; but he did not agree that the youth should go there to begin with, because he thought a young apprentice should be actually at work first. It was well for him to know the use of the tools in his trade, and in gaining that practical experience he would find his first incentive to a fuller knowledge of the business. At the science school afterwards he would be able to assimilate theory with practice. If he came from the college first, he would turn up his nose at the practical work and ask "why he should mess his hands with this beastly job." If the boy began without some practical experience at a technical college, the professor spoke to him about what he did not understand; but going from the workshop, he grasped the why and wherefore at once. "Yes," he will say, "I have seen that engine design in the drawing office, or that mechanism in the workshop, but did not quite understand. Now I see the meaning," and not only had he the knowledge, but he had reached an age when he could more thoroughly grasp these things. So he said distinctly that it was advisable apprentices should first go into the shops and afterwards to the science college. He quite agreed with Mr. Borrowman that the prosperity of this country is primarily due to the engineers. He thought that was the pith of the paper.

Mr. Robert Thompson: What about Noah's Ark?

Mr. Westgarth: Well Noah's Ark went ashore! The only other remark he had to make was that he thoroughly agreed with Mr. Borrowman as to the course of education, and he thought a great deal more attention should be given to the teaching of modern languages. It was deplorable the amount of ignorance there was amongst Englishmen. Comparatively few could speak a foreign language, and that was a point that should be pressed upon parents, not only for engineering and shipbuilding, but for mercantile business, that boys should certainly study modern languages.

Mr. J. R. Fothergill thought that in the first place they should congratulate themselves that a gentleman in Mr. Borrowman's position was willing and ready to come forward to express the opinions he had on such an important and interesting question. He thought they might take it as a very healthy sign of the times. The question of the training of engineers was always one of a very debatable nature. Although he agreed with much his friend Mr. Westgarth had said as to the necessity of a thorough apprenticeship in the shops, yet he could not altogether agree with him that practical utility was acquired by assimilation to the extent and advantage Mr. Westgarth considered. Of course, a lad who, in moving about a shop, kept his eyes open and noticed what was going on, learnt much, but he was of the opinion that it was only by being engaged on the work itself that the lad obtained a thorough knowledge and became a proficient workman. The question of apprenticeship and the course of training appeared to him to resolve itself into two classes. Apprentices who in the natural course of things will remain working men and those who will succeed to higher spheres. He thought all should commence in the shop under similar conditions, and be encouraged to attend technical classes in the evening, and those who proved industrious, painstaking, and showed special aptitude, should have the preference in promotion. This appeared to him to be essentially the employers interest as well as the apprentices. The question of a thorough practical training in the shop was a commercial question, and one for the employer to decide. Works were not run out of philanthropy, but as industrial undertakings, and unless it would pay, employers could not be expected to give that shop training during apprenticeship which he should like to see. Personally he felt that experience would prove that it would pay. Trained workmen would of necessity produce better work and be more reliable, trustworthy, and profitable, and those who advanced to higher positions would be better qualified and better able to undertake such duties. Then arose the question of education, so ably treated by the author in his paper. It was astonishing, the diversity of views on this question, particularly in reference to those youths who had the opportunity of a college education. There were those who advocated the usual course of attendances at colleges, such as the Durham College of Science, Newcastle, prior to entering the shop. Personally, he did not take this view, but agreed with Mr. Westgarth that a youth more seriously and earnestly took to shop work and dirty hands after leaving school than he did after attending college. Of course there were exceptions, but from experience he was strongly in favour of entering the shops

first. Others advocated six months in the shops during summer and the six winter months at college. He was aware several employers had agreed to this, and that such attendance at college should count in apprenticeship. He felt considerable hesitation as to the advisability of this course. He felt a five years apprenticeship was not too long in the shops, that is if a youth was to attain a practical knowledge in the various departments, and he failed to see the advantage in sacrificing a year or two of apprenticeship when, in his opinion, college could be attended with greater satisfaction after apprenticeship. He favoured the opinion that a youth should enter the shops first and complete a five years' apprenticeship, and during his apprenticeship be encouraged to attend technical classes now existing in nearly all towns. This was of essential benefit, and well prepared and fitted him to attend later a science college. In the building in which they were met (the Technical College) the classes were exceedingly well attended. They would be astonished at the number of apprentices from the various works who attended, and as this attendance was purely voluntary, it was indeed satisfactory, as one realised that young men thoroughly saw, if they were to make headway in life, they must take full advantage of such classes. What he desired to see was employers offering every encouragement and facility to their apprentices to attend evening classes. He was aware there were times of emergency when overtime could not well be avoided, but he appealed to employers in ordinary times to allow those apprentices who attended evening classes to be exempt from overtime, he felt sure this could be so arranged as not to interfere with the organization or discipline of the shop. He had seen classes completely broken up by students having to work overtime, and when a student missed two or three attendances in succession, he drifted behind, lost interest and finally withdrew, often disgusted. This was deplorable. He felt sure it must be to the interest of employers to have intelligent apprentices, and the fact that attending classes was purely voluntary was undoubted evidence the lad had "grit" and meant to do his duty. In the Hartlepools a considerable number of the engineering apprentices gravitated to sea as sea-going engineers. It certainly did seem extraordinary that so little or no effort was made to specially train them, at all events a percentage of the more intelligent apprentices, to enable them to properly fulfil the important duties of junior sea-going engineers, particularly when one considered the number of junior engineers the manufacturers of large marine engines sent to sea with the large and costly engines of the present day, and which they guaranteed. A junior sea-going

engineer required to know how to handle his tools, and a good practical knowledge of detail and general arrangement of the various parts, and as he often had in the early stages of his experience, particularly in steamers carrying three engineers only, to at once take a watch on joining, it was manifestly to the detriment of the highest efficiency of the engines and reputation of the manufacturers that such untrained men should be put in such responsible positions. Had time permitted, he could give some sorry illustrations. He quite realised much of the difficulty employers experienced at the present day was due to commercial requirement necessitating sub-division of labour, by which an apprentice became proficient in one thing and knew little or nothing of anything else. He quite understood the difficulty, and if, commercially, it was found impossible to give a more varied training, there was only one alternative he saw, and that was to associate with technical schools a complete engineering laboratory. He desired to thank Mr. Borrowman for his very able and well thought out paper. Although somewhat academic, he could have wished that Mr. Borrowman, particularly with his large practical experience, had treated the subject more practically in a definite manner. The paper was of great value, and he hoped it would be thoroughly discussed. In conclusion, he appealed to employers to give greater consideration, more thorough training and general encouragement at all events to those apprentices who showed such a desire to improve themselves, particularly by voluntarily attending technical classes.

Mr. Ernest H. Craggs said there had been some reference by previous speakers to the skill and ability of our engineers and the important part they had taken in the making of our empire. He could not believe that those words, coming as they did from well-known marine engineers in this district, were seriously intended to hint at a monopoly of such service to our empire by the particular class of engineer to which they themselves belonged, the marine branch of mechanical engineers. He thought with Mr. Borrowman that our empire owed a great deal to their engineers, and would owe more in the future. If the marine engineers had no objection, he would, on the part of all the shipbuilders present, humbly ask for them a place among this greater family of engineers.

It was impossible to ignore the fact that the greatest historical writers of the present time, while they agreed that England's supremacy owed not a little to the excellence and extent of her manufactures,

maintained that her maritime position and naval power, the latter even at the time when marine engineers did not exist, had still more to do with her premier position among the nations, which was practically won at the beginning of the 19th century.

Now surely no one would deny that shipbuilders had some small part in the building of our navies ?

He had not very much direct criticism to offer on the paper. He thought such criticism would be sufficiently given by those more closely connected with the control of the engine shops. Their debt of gratitude to Mr. Borrowman they all acknowledged was deep, and most sincerely he acknowledged his own. They must, he was sure, now recognise in Mr. Borrowman an expert in education—his paper was distinctly confirmatory of this—and more especially would he say of technical education, as well as an expert in the erection of the well-known marine machinery for which this port was so justly famous.

In listening to the paper, it had come to his mind that truly the road of the apprentice was strewn with many thorns, and brought him to the foot of many difficult "kopjes." There were many troubles through which the apprentice must gradually rise to be what he ought to be, and he (Mr. Craggs) thought he would have to live very many years to complete his course properly. He thought that in Japan, of all places in the world, he would least like to be an apprentice, especially if he was going in for the "first class." He was inclined to think that if he had been compelled to choose as a boy he would have run for a "third"! Mr. Borrowman, he thought, did not really hold up the Japanese system among those described as one they should adopt, but his aim was rather that they should take care one way and another to keep ahead of them all. He thought that the country in their military operations and other affairs had lost a great deal in not recognising that there were men in England who must be brought forward quickly, and not kept out waiting until all others in places of higher responsibility had been removed by the hand of death. Never before did the country need such men as she did now, when competition was seriously threatening, and she could not and must not wait for them, to guide her trade and manufactures, and give their skill to handicraft.

He said that they must beware how long they argued amongst themselves how apprentices were to be brought on, and quickly come to a conclusion what system they were going to give them, in cases where a system or an improvement was called for in our own works ; for it was not so much for them to demand that they be skilful apprentices, as to see that they have skilful teaching.

The phrase in the paper that struck him most was "the method of learning how to learn." In this they could find their cue for all sound teaching of apprentices. The sooner they made up their minds individually whether schools were to be first and then the shops, or the works first, then the schools, or both taken together, the better.

He could only add that they should not forget the debt of gratitude they owed Mr. Borrowman for bringing these things before them, and he sincerely hoped the Institution would take some specific action in the form of a recommendation to their members, for which he thought their ordinary machinery was quite sufficient, and thus bring some satisfactory and tangible result from this interesting discussion.

Mr. Robert Thompson said he had been very much interested in the paper Mr. Borrowman had read. He thought shipbuilders should receive some credit for the present position, because if it had not been for Noah's Ark they would not have been there that day; but it was to the engineers they looked more and more for the future prosperity of this country. The education of young prospective engineers was an important matter. There was nothing in the board school teaching to fit or bias boys for any particular trade. It proceeded in certain grooves in order to win grants. He saw an instance of the result not long ago. A young man who had passed the highest grade in a board school, when put to address an envelope did not know how to do it. When a lad at school showed an inclination for some particular line of life, he thought he should be encouraged in that direction. A teacher would really have more influence than a parent in deciding for the boy. All the teachers thought of, however, was how they would obtain a certain grant per head—that was the main consideration, and not that the education should fit the boy for the life he had to live. They were passed through the same grind whether they were to be drapers, butchers, or engineers. Now, he thought that after the scholars had got to a certain standard of general education, the remainder might be more adapted for the trade or occupation they proposed to follow. In that way they would be more fitted than at present to assimilate what they saw and heard in the shipyard or engineering shop. He knew in Switzerland, for instance, if a lad was going to be a merchant, he was not put to learn geometry or Greek, but how to keep books and balance accounts, so that no sooner was he placed in an office than his tuition became at once serviceable. He was quite sure if more attention was paid to the indications of a boy's mind and aptitude for different trades,

there would be better results all round than at present. It was a moot question whether a boy should go first to a college or the shop ; but he (Mr. Thompson) did think this—that if a boy got too old before he went to work, it was most difficult to teach him. He thought the sooner a lad learnt to work with his hands the better ; and then follow on with the technical schools in the evening. They would get the best results from a boy taught in that way. He thought much good should result from the paper.

Mr. Henry Gibson felt very much indebted to the writer of the paper, but as a shipbuilder he could not quite agree to all that had been said. With reference to boys receiving a special education to fit them for their work in life, this would be of great advantage to those who could depend upon securing a definite appointment, but we must remember that there are hundreds of boys who have not this privilege, and have to take such employment as their parents may be able to secure for them. Many who would like to be shipbuilders become engineers, and others who would like to be engineers find their way into shipyards and other places. With regard to the desirability of practical or technical knowledge coming first, he believed it was best that the practical should be taught for the first two years of a youth's working life. He had had some experience in the training of apprentices, and found that those who had been at college for two or three years proved less capable workmen than others who had received their practical training early in life.

There were many things to be considered in making a capable workmen. A man may be mathematically correct, and all his work exactly done, but there was the question of cost. The man who had first received a practical training could usually make the work pay better, and this is an important matter.

It seemed to him that the early college training unfitted a youth for the more arduous labour of the workshop.

With reference to foreign competition, and the better education referred to in other countries, he believed every man should secure the best education possible no matter in what position in life he may be placed, and wise on the part of the authorities to give all the assistance they could.

As to the sub-division of labour, it would seem as though many people regarded this as an evil state of things, and only brought about by employers to facilitate work for their special advantage. He believed it was also a great benefit to the men.

They had men in shipyards whom it would be very difficult to teach marking and working from plans, and yet these men could manipulate machinery, and prepare plates with accuracy and despatch when marked by a man skilled in this work, and the other man would probably not be able to work machinery to the same advantage.

Mr. M. C. JAMES did not profess to be able to speak authoritatively regarding the training of engineers, but as one who had had upwards of ten years special experience in the teaching and training of shipbuilders, he could not agree with the view taken by Mr. Borrowman that a lad should, after leaving school, then proceed to a technical school before starting his apprenticeship to a trade; in fact, he considered the present system of technical education worked fairly satisfactorily when there was the right kind of students and suitable teaching. An ounce of facts, it was often said, was worth a ton of theory, and he could point out some gentlemen now in that room, former students of his, who had gone direct from school to work, attended evening classes during their apprenticeship, and who now occupied leading positions on the official staffs of some of the principal shipyards on the Tyne and Wear. Moreover, he had known many better class working men who had endeavoured to improve themselves by studying at night classes, and they now held responsible posts in various yards throughout the kingdom—one in particular occupying a very prominent position with a celebrated shipbuilding firm in Dumbarton. There were many difficulties, too, in the way of ordinary lads adopting such a course as Mr. Borrowman suggested—there was the all-important one of £ s. d, where, in most cases, a lad must needs earn a wage as soon as possible after leaving school, and there were also the trade union rules stringently restricting the choice of a trade, and the time of entering it. Most trades unions, such as the boilermakers' and the engineers' societies, took little or no active interest in the technical education of those who were to become their members; now, in his opinion, if a trades union ordered, as they did do, that when a man, having become a journeyman, and one of their members, he must be paid a certain rate of wage, then, surely the employer should be in a position to say: "You must supply me with a properly trained and technically educated tradesman for the wage demanded." He (Mr. James) considered the responsibility for the training of apprentices should be largely shared by the trades societies, they should not admit men as members until they had not only served an approved apprenticeship, but also gone through a suitable course of

technical instruction; unfortunately, however, so far as his experience went, most trades unions were absolutely callous and indifferent in the matter. He begged to thank Mr. Borrowman for his very able paper.

The PRESIDENT said engineering education was a subject to which he had given a great deal of thought. When they talked about the "best system," he doubted if there was such a thing as the best system. The only thing they could do was to give facilities for the acquirement of correct knowledge, and allow each individual to work it out in his own way. There was hardly any system but what turned out first-rate men. There was no system in which some men were not turned out as wasters. He thought the education should be left very much for the young men themselves to deal with, each according to his own circumstances, talents, and opportunities. For example, at Newcastle they all knew more or less the Elswick Works. They had been very successful indeed; but their founder, Lord Armstrong, was, up to the age of, I believe, 38, trained in a solicitor's office. His two next right-hand men—Sir Andrew Noble and Colonel Dyer—both attained considerable standing and distinction as artillery officers before they became professionally engineers, yet, as is well known, they were most successful in their new calling. He did not from this, advise all of them to begin in a solicitor's office, or to enter the army but still this showed them how it was impossible to dogmatise as to the best possible training. It was exceedingly difficult to teach a handicraft in college, and, as far as he had been able to observe, where they had got a number of young, inexperienced men, with perhaps, a professor, an assistant, and only one or two journeymen to teach a large number of lads, it was almost impossible to keep up a high standard of work, and one thing he felt sure of was this, that it was of the greatest importance for young men to see nothing but really first-class work about them. Their best training was to see good work, and there never was a time when such a quantity of high-class work was turned out as was turned out now. There were the many requirements caused by the use of high pressure steam, also complicated electric apparatus, new guns, and firearms of every class, some of which, as regards design, were looked upon as novel, which really are not so. For example, to speak generally, breechloading guns, which were only successfully adopted about 40 years ago, were known long before our grandfathers were born. They were no use, however, because the people had not the appliances and machinery necessary to make the breechloading apparatus gas tight to withstand explosion, and so the

the idea was valueless because the mechanism was imperfect. If mechanics now had to range over a smaller field of operations, they had to produce better work in that field. There are no doubt a certain number of men and boys labelled mechanics who are very poor creatures. I have heard a "skilled mechanic" defined as "man who can file straight," and there are a few, but probably very few, who are content not to rise above that low standard. Now, as regards a boy thinking he was part of a machine, or that the machine did all the work, really, when he begins to realise his position, he also begins to know how to modify its action and improve the results, he would learn all the parts, and instead of being the servant he would become the master of the machine, and be prepared at any time to re-arrange its details so as to bring about a better organisation. He was inclined to think that a young man who learned to classify his work, and can control and modify the methods by which it is done, and co-operate with other men in bringing about good and economical results, was a higher class of engineer than the man who merely was skilled with his fingers. In regard to the paper he would like to thank Mr. Borrowman for the research and study embodied in it. It was exceedingly interesting and almost an unique report, on the technical instruction carried out in other countries besides England. He (the President) would give all young men this piece of advice, they ought to know themselves. That would teach them what no other body could teach them to find out talent or aptitudes—it might be designing, or it might be quickness at work, or perhaps to be a good man in the engine room of a ship; but let each one make up his mind as to where he felt he excelled, and then concentrate his energies into that channel, and perfect himself in that line. But he ought to try up to a certain age to be a good all-round man before becoming a specialist. He had tried very hard himself as far as he had had opportunities, to give all apprentices the best chance possible. In the works with which he was connected they put their apprentices through a certain course of machines and other work, so that by the end of their apprenticeship they should know the whole of the workshop. They all had very much reason to be thankful for the class of men growing up around them.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899–1900.

PROCEEDINGS.

SIXTH GENERAL MEETING OF THE SESSION, HELD IN THE MARINE SCHOOL, SOUTH SHIELDS, ON FRIDAY EVENING, MARCH 23RD, 1900.

ROBERT HOME MUIR, ESQ. (MEMBER OF COUNCIL), IN THE CHAIR.

The SECRETARY read a telegram from the President (Sir B. C. Browne) expressing regret that he was unable to attend the meeting.

Mr. R. H. MUIR, a member of Council, was asked to preside.

The SECRETARY read the minutes of the last General Meeting, held in West Hartlepool, on February 24th, which were approved by the members present, and signed by the Chairman.

The ballot for new members having been taken, the Chairman appointed Messrs. W. Dalrymple and E. J. Crosier to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Christie, David M., Engineer, 95, Great Western Road, Glasgow.
Hyslop, Alfred M., Marine Engineer, c/o Messrs. Boothroyd and Co., Akenside Street, Bootle, near Liverpool.
Lange, E., Engineer, 18, Walbrook, London, E.C.

GRADUATES.

Bullen, Thos. H., Draughtsman, 14, Bede Burn Road, Jarrow-on-Tyne.
Fletcher, Arthur C., Engineer, 5, The Avenue, Wallsend-on-Tyne.

The Discussion on Mr. S. J. P. Thearle's paper on "The Distribution of Materials in the Upper Works of Large Steamers" was resumed and closed. Mr. S. J. P. Thearle replied to the remarks made.

The Discussion on Mr. W. C. Borrowman's paper on "Some Considerations Affecting the Training of Young Engineers" was resumed and closed.

The SECRETARY read a paper by Mr. W. H. Atherton on "The Fouling of Ships." A discussion followed which was adjourned.

RESUMED DISCUSSION ON MR. S. J. P. THEARLE'S PAPER ON "THE DISTRIBUTION OF MATERIALS IN THE UPPER WORKS OF LARGE STEAMERS."

MR. R. H. MUIR said, it seemed to some of them only yesterday since Mr. Thearle came amongst them. That was the first paper that he had read before that institution, and in it he had simply given them a foretaste of what they might expect in the future. To most of them Mr. Thearle was a stranger. He had come from the Clyde to the Tyne, and he was honourably connected with a society (Lloyd's Society), which society, in its wisdom, had, within the last few days, chosen him as one of its chief surveyors. The speaker presumed, possibly, to express the sentiments of those present, and wished him every success and prosperity when he went to London. At the same time, their feeling was not unmixed, because they would very much regret his absence from the Tyne. Mr. Thearle, in his paper, said, "It is not supposed that anything contained in this paper will be new to the members of this institution, but it is thought that, being put upon record in this way, the opinions stated may lead to a profitable discussion." The speaker took it that Mr. Thearle had given them a record of the advance and development in shipbuilding during the last 10 or 15 years, a development of which shipbuilders were justly proud because it was a development on rational and scientific lines. It had marked a period more definite than any previous page in the history of shipbuilding. Mr. Thearle also said: "In bringing these remarks to a close, the writer desires to say how pleased he is to be able to testify to the careful manner in which the principles he has brought before you have been recognised in the work carried out on the Tyne." The speaker did not for a minute imagine that Mr. Thearle meant less than he said, nor that he meant to flatter the builders on the Tyne. It was simply a recognition on the part of a gentleman who had had a very wide experience on the Clyde and who came to the Tyne and found that the builders on the Tyne were actuated by such desires on their part not only to give to the shipowner a profitable structure, but a structure for which they could feel that some credit was due to themselves. Therefore the speaker thought that that recognition on the part of Mr. Thearle from his survey of the yards on the Tyne was certainly very creditable to the builders on the Tyne.

Mr. S. J. P. Thearle, in reply, desired to tender his thanks to the members for the very kind reception afforded to his paper, and for the criticism which they had given to it. Commencing with Mr. Hogg's remarks, he would say that he sympathised with him in his desire to have the immersion of a vessel governed, among other things, by her strength; and this principle was adopted in the application of the Board of Trade Rules and Tables for freeboard to spar deck vessels. But, as he was aware, the freeboard of a vessel of full scantlings was based upon reserve buoyancy and not upon strength, it being assumed that the strength was sufficient to meet the stresses due to any additional immersion allowable on account of the deck erections. Mr. Hogg said that in such a case the vessel of full scantlings with short erections would be unnecessarily strong if the one with long erections was strong enough. He could only reply that to determine separate sets of scantlings for not only vessels of different dimensions, proportions, etc., but also for the varying lengths of erections which each vessel might have, arranged in the many different ways in which they might occur, would be an interminable task. It would, of course, be possible, but he imagined in ordinary shipyard practice it would be found impracticable. He offered no objection, but the contrary, to reverse frames being extended to a bridge or a shelter deck when the side plating, etc., of the erection was additionally thickened, and perhaps he was in error in supposing that shipbuilders would not be desirous of treating deck erections in that manner. Certainly, if the framing and plating of a continuous deck erection were made of the scantlings ordinarily assigned to the upper deck it would scarcely be correct to describe such an erection as a "shelter deck." Regarding Fig. 2 (Plate XIX.), he should mention that this sketch was not exhibited with a view to showing the additional height of 'tween decks, but merely as an actual case of a shelter deck vessel. He was sorry that he was unable to furnish Mr. Hogg with any further information regarding it. He had made no calculation regarding the case shown by Fig. 3 (Plate XVIII.), but he knew that the vessel was at work and had shown no signs of weakness. He thought it was to be regretted that Mr. Denny should have disfigured his otherwise interesting communication with allusions to Lloyd's Register, having no bearing upon the contents of his paper, and which were in no way calculated to assist in the useful and friendly discussion of it. A portion of of his reply to Mr. Hogg's criticism would apply to Mr. Denny's also. He knew something of Messrs. Denny's practice after eleven years' attendance at their yard, but he felt bound to state that whatever might be Mr.

Denny's opinion on the subject, he never yet knew his firm to extend reverse frames to the height of a bridge deck.* He was glad, however, to see that both Mr. Denny and Mr. Sivewright advocated the fitting of substantial framing whenever a considerable transference of materials to the upper works had been made, as he had known cases in which it had been argued that if the plating were thickened there was the less need of stout framing behind it. Mr. McGlashan did not admire the position of the sheerstrake butts in Fig. 1 (Plate XVIII.) and he must confess they were not exactly where one would wish them to be. The sketch was not shown as an ideal butt arrangement, but to show an actual case which was that of a passenger vessel doing her work very satisfactorily. As Mr. McGlashan well knew, it was not an easy matter to arrange all the butts of side plating, doublings, stringers, etc., so as to keep them as far clear of ports as one could wish, and in this case the precise positions of the doors were not known when the shell butts were arranged.

He now had the pleasant duty of thanking Mr. Muir for his very kind remarks in regard to himself and his paper. Mr. Muir had spoken of his (Mr. Thearle's) reference to Tyne shipbuilding and his opinion thereon. He came to the Tyne after a sixteen years' residence on the Clyde, which river it had often been impressed upon him was the hub of the universe as regards shipbuilding, also that no good thing could come out of the North-East Coast. That was a very common and erroneous impression. He, however, had found, as he had expected, that the work on this river was as good as any he had been accustomed to. He had had a very pleasant stay on the Tyne during the seventeen months he had been there, and he trusted that his duties would enable him to come to the North occasionally, and if they did he hoped that those visits would coincide with the meetings of the Institution, of which he would always be proud to be a member.

On the motion of the CHAIRMAN a hearty vote of thanks was accorded by acclamation to Mr. Thearle for his valuable paper.

*EDITOR'S NOTE.—The Secretary has received the following letter from Mr. S. J. P. Thearle:—

LLOYD'S REGISTER OF BRITISH AND FOREIGN SHIPPING, NEWCASTLE-UPON-TYNE.
May 12th, 1900.

DEAR MR. DUCKITT,

With reference to the remarks made by me recently at South Shields in reply to the discussion on my paper, I desire to state that Mr. Archibald Denny has given me satisfactory evidence of his firm having, in at least two instances, extended reverse frames to a bridge or shelter deck.

Yours faithfully,
S. J. P. THE

DISCUSSION ON MR. W. C. BORROWMAN'S PAPER ON "SOME CONSIDERATIONS AFFECTING THE TRAINING OF YOUNG ENGINEERS."

Mr. D. MYLES said he thoroughly agreed with Mr. Borrowman that apprentices to the engineering trade while serving their apprenticeship should at the same time study the scientific and technical side of the subject. Anyone who saw the very rapid advancement of some of our continental rivals could not but consider what was the reason for their advance. In some cases they had quite outstripped us, and he thought that it was very largely due to the greater attention which they paid to the training of their apprentices. At the works with which he (Mr. Myles) was connected, the firm every year gave prizes to the apprentices who attended evening classes. These prizes were awarded on the results of the Government examinations held at the end of the session, and also attendances at any other classes or lectures. Out of the number of apprentices employed the per centage who sent in the necessary returns for the prizes given by the firm was disappointingly small. That was confirmed by the experience he had in connection with science evening classes. In large districts like what they had on Tyneside the number attending these evening classes was very small indeed, and if something could be done to make it obligatory on apprentices while serving their apprenticeship to attend evening classes, making it part of their training it would be a very great improvement, in his opinion. He would not at all advocate reducing the length of apprenticeship in the shops, he thought that five years was quite as short as it should be ; but he was strongly of opinion that after an apprentice had finished his day's work in the shops, he ought to continue by going to the evening classes, two or three nights a week at any rate ; and if it were possible to devise some means whereby firms, when they start apprentices, should make it a condition that the apprentices should attend some classes he thought it would be a very great improvement ; he thought the subject treated by Mr. Borrowman very opportune and ought to do a lot of good.

Mr. S. J. P. THEARLE said he would like to mention in connection with the remarks just made by Mr. Myles, that in the Royal Dockyard it has been the practice for at least fifty years past to insist upon every apprentice attending classes in the Dockyard Schools on two evenings

and two afternoons of each week during the first three years of their apprenticeship. He understood that an engineer apprentice in this district worked from six in the morning until five in the evening with the usual intermissions for meals, and he thought that if the lad had done a fair day's work he would not feel very much inclined for the further fatigue of night study. In Her Majesty's service that consideration was recognised, and so the apprentices were allowed to leave their work an hour or so before the usual time so that they might rest themselves, change their clothing, take tea, etc., before commencing their evening studies in the school. The time for the afternoon classes was paid for by the Government the same as if the apprentice had been at work. This system extended over the first three years, and the apprentice was allowed to continue his studies for a fourth year if found to take proper advantage of the privilege. Whether or not his studies were further extended depended upon his position on the half-yearly examination list. If of exceptional ability, the studious young man might attain a free studentship at the Royal Naval College which opened the way for the highest positions in the constructive department. He (Mr. Thearle) considered that if an employer wished that this kind of education should be added to the training afforded in the shops, he should assist by giving the young men a portion of the time which would otherwise be devoted to their work to enable them to attend classes, and not expect the apprentices to study for several hours after working from 6 a.m. to 5 p.m.

Mr. W. Dalrymple said no doubt the education of the engineer was a very important matter; but, at the same time he thought an engineer was "born, not made," and no education in the world would make a man an engineer if he was not born one to begin with. A considerable percentage of the youths were apprenticed to engineering simply because they could not get to anything else. It was such a difficult matter to place a lad in business that parents were glad to get them to work at anything, so the lad might be at a business for which he was unsuited. Many went to be fitters and pattern makers who might have been better in grocers' shops and others, no doubt, were in grocers' shops who ought to have been mechanics. He thought something should be done to assist any youth who would take the trouble to attend science classes in the evening after his day's work was done. Such youths ought to be encouraged by every means. He was speaking from experience. When he (Mr. Dalrymple) was an apprentice, they worked from six

o'clock in the morning to six at night. It took a very great deal of zeal in engineering after getting home to attend classes held then in the School of Art, Newcastle. He thought more could be done for such attendance by giving those willing to attend the classes a little more time to enable them to do so.

Mr. R. H. MUIR said the paper dealt with a subject upon which it was impossible to come to a unanimous conclusion. Up to 15 or 16 years a boy received the ordinary school education. It then became necessary to find the bent of his mind and the future education should follow that course. If he chose engineering he should go into the shops for two or three years, not neglecting his studies meantime, still not making him altogether one-sided. That portion of the paper which said the boy ought to have a hobby outside his main work, he fully endorsed, be it music, astronomy, classics, or whatever he liked best, but it must be something—plus exercise, and, first and foremost, *he placed volunteering*. What was most desired was to make good all-round men of them.

The following communications have been received by the Secretary :—

DEAR MR. DUCKITT, 59, BATH STREET, GLASGOW.

I have had great pleasure in reading Mr. Borrowman's paper, more especially, since I have the honour of claiming him as one of my most successful old students. From a continuous experience of twenty years teaching, I have been lead to the conclusion, that the education and practical workshop training of mechanics, draughtsmen, managers, and possible owners of engineering works should be differentiated as far as possible, from the time youths have passed through their elementary education. One cannot lay down absolute hard and fast lines for each class, in the same rigid way, as has hitherto been customary by the authorities in the case of applicants for the church, law and medicine, or for the navy and the army. Nevertheless, seeing that the old system of a continuous 5 to 7 years' workshop apprenticeship has undoubtedly broken down, in respect to those who aim at the higher branches of the engineering profession, we have to consider most carefully, how each section of the great body of mechanics and engineers may most profitably spend the years between the preliminary day school and their making a living wage or income. Of course, there should, and there will, always be opportunities for the steady, industrious, clever lad forcing his way from the poorest circumstances to the highest and most lucrative positions, whatever courses may be laid down for the average person : just

as in the prominent and recent case of General Hector MacDonald, naturally rising from the ranks to the command of the Highland Brigade, on account of his innate soldierly characteristics.

Home and foreign competition has so stimulated the inventor to devise special self-acting tools, and masters to elaborate the divisions of labour, that the all-round millwright stamp of man has almost disappeared. Consequently, those who wish to become mechanics and nothing more, have to be content with learning one branch of a trade. Moreover, should they desire to learn more, both masters and men are hampered by the several trades' unions (who lay down such rigid and narrow-minded rules in regard to the number of apprentices for each class), that there is much less latitude permissible nowadays, than used to be the case some thirty to forty or more years ago. I have been in the habit of suggesting the following courses for the different sections, and I believe, that if faithfully carried out, they will be found to be even more exacting than what is usually demanded :—

For Mechanics.—(1) A good school board or elementary education up to the end of the sixth standard, or at least until the lad is 13 or 14 years of age. (2) Five years at one branch of the trade, such as pattern-making or turning, or fitting and finishing. (3) Coincident with the workshop, regular attendance at evening classes during the winter months. This course should be so carefully graduated that a lad cannot take more than two subjects each winter, and that arithmetic, freehand, and mechanical drawing with special reference to his trade should form the basis for any subsequent science and evening trades' classes. (4) Volunteer drill and target practice, &c., during the summer evenings. Masters should on no account be encouraged to pay the small evening class fees demanded for attendance at any one of the many excellent junior evening classes now to be found in every busy centre of industry. The youth should rather be stimulated to save up sufficient money from his apprentice wage to pay for classes and books, or to compete for an evening class bursary, when he will all the more thoroughly value the instruction and privileges thus afforded him. The masters should, however, be asked to note the classes attended and the progress made by each apprentice, and give him due credit for the same, in conjunction with his steadiness and skill as a workman, when he has completed the agreed upon term of apprenticeship. An effort should also be made to so interest the "Trades' Unions" that they shall also recognise evening classes, as has been most successfully done in the case of the National Registration of Plumbers. Further, there is no great difficulty in teaching different

subsections of a trade to senior apprentices in evening classes. This has been carried out with gratifying results in Glasgow. For example, the plumbers have here practical evening workshop classes in addition to the regular course of lectures. Thereby, those who may not have had experience in their master's workshops in certain kinds of jointing, or in making the latest devices for sanitary appliances, can do so, and thus be all the better prepared for their journeyman's examination, which consists not only in sketching and describing apparatus, but also in proving that they can handle different tools and make different things in a workman-like manner, and within a reasonable time.

For Draughtsmen.—(1) A good sound secondary education (but without any Latin or Greek) up to 16 years of age, or the passing of the junior leaving certificate of the Education Department. (2) Three to four years in one or, if possible, two departments of a workshop, where one should be pattern-making or moulding, and the other fitting and erecting. (3) One to two years in the drawing office, until the five years of apprenticeship have been completed. (4) Evening classes throughout the whole five years of apprenticeship. These classes to be so graduated and arranged that not more than two subjects are studied during each session. These subjects should include mathematics, engineering drawing, natural philosophy, mechanics and steam ; in fact, everything that is covered by the senior evening class certificate in the engineering section of a good technical school or college. (5) Volunteer drill and target practice, &c., during the summer evenings.

For Managers and Owners of Works.—(1) A sound secondary education, including two modern languages, up to 17 or 18 years of age, or the passing of the senior leaving certificate of the Education Department. (2) Three winter sessions (5½ months each) at the day classes of a good technical college, with the two intervening times (5½ months each) in an engineer's workshop.* (3) The remainder of the five years should be spent in the works and drawing office, together with attendance at senior evening engineering classes during the winter months, and volunteer drill and target practice, &c., in the summer months. During the time that the pupil is at college, he should aim at obtaining the engineering diploma of the Institution where he studies, and of passing the

* I should have stated here that I do approve of workshops in connection with Technical Schools; for thereby, many youths and their parents may be saved much after-pain and disappointment in finding out, or from being informed by the teacher, that the aspirant has no turn for mechanical work, and should turn his attention to some other calling without attempting to become an apprentice engineer. Mr. Borrowman very properly mentions other uses of such workshops.

Entrance Examination for the Studentship of the Institution of Civil Engineers. Should he have a special aptitude for study and his parents are able to afford it, he may be encouraged to ultimately take the B.Sc. in Engineering Science at one or other of our universities, and of passing the examination for the associate membership of the Institution of Civil Engineers. When he is in the workshop and drawing office he should aim at understanding how to manage men, tools, and methods of doing work to the best advantage, in addition to the effort to become a fairly skilful and by no means slovenly workman. He should as far as possible study "workshop administration, with special reference to tracking work, and promptly ascertaining detailed costs and profits."* Whilst he is a volunteer he should aim at ultimately becoming an officer of volunteers.

I very soon found, that it was quite useless to expect young men to go for part of a day to a works, or to an engineer's office, and then come to college for the remainder to day classes; and hence, I instituted in the College of Science and Arts, Glasgow (now the Glasgow and West of Scotland Technical College), a 5½ months' winter session, where the student must attend the college *only*, and go *wholly* to a works for at least the other 5½ months of the year. The English system of having three short college terms, so breaks up the year, that work-managers are most unwilling to take on young men for a few weeks at a time; whereas, they do not object to doing so, in fact they are quite pleased to try a young man for 5½ months on end, if he has a good record for the previous 5½ months at the day classes of a technical college, and promises to come back again after the following session.

In a paper which I read at the International Congress of Electrical Engineers in America, during the Chicago Exhibition of 1893, I put before engineering educationalists and "master mechanics" the results of this plan, and they all admitted that it was far preferable to many of the other inextricably mixed-up methods of educating the young engineers of the higher or wealthier order. In America I found, however, that the school and college teachers believed greatly in their workshops, as compared with our system of sending young men into a regular engineering works. There can be no doubt about it, that in the expensive school and college workshops of America, wherein they have some very fine tools and a very perfect system of supervision, with skilled mechanics to train the young men how each piece of work should be done to the best advantage, they do turn out very neat mechanicians

* See the Proceedings of the Institution of Engineers and Shipbuilders in Scotland, April, 1900, for Mr. David Cowan's paper on this subject.

and some clever inventors. These same young men do find good positions afterwards in works, although they may not be, and do not aim at being, actual skilled working-men at the vice, lathe, or tool bench. After, but not before the apprenticeship is over, the fully fledged young engineer should be encouraged to join one or more of the many Engineering Institutions, such as the one before which Mr. Borrowman's paper was read. Since these engineering institutions have as a rule what is variously termed a "Graduates'" or "Students'" section, the newly enrolled junior member can so gradually take part in the discussions and the writing of papers, that before he advances to associateship or to full membership, he will have so thoroughly overcome any natural shyness and inability to express himself clearly and to the point, that he will take a perfect pleasure in studying the views of others, and of keeping abreast of the times in more than one branch of engineering; although, he may perforce have to gain his livelihood in only one department thereof. At least, he will conclude that he is not yet too old to learn from others what their views are, and to be thankful for the chances which he had, in being taught systematically how to learn. Yours faithfully,

ANDREW JAMIESON.

MUNICIPAL TECHNICAL COLLEGE,
WEST HARTLEPOOL.

DEAR MR. DUCKITT,

In making a few remarks on Mr. Borrowman's excellent paper, I think it may be taken for granted that the question as to whether our young people are to be technically educated or not has been settled for us long ago. We must give them a sound practical and theoretical acquaintance with the industries in which they are to work. The great need of the moment is that employers of labour should be brought to recognise this fact. It is sad to think that there are so many employers of labour who still rely on the position that England got on very well in the past without technical schools. They forget that the conditions of to-day are entirely changed. We got our supremacy from a number of political and other causes, which no longer operate. We have now to defend our position against the most determined and the best equipped foes, and for this warfare the best possible training is needed. The old apprenticeship system is not exactly suited to modern conditions and it is falling into disuse; but a substitute for it is wanted. So many and various are the branches of any great modern industry, that it would be impossible for the employers to undertake, as they used to do, that every youth committed to their care should learn all; and, indeed, a lad of ordinary ability would be bewildered by the attempt. But it does not seem impracticable to revive the apprenticeship system in a

modified form. The plan of spending the six winter months of several years after leaving school in learning science, and the six summer months as articled pupils in large workshops can only be adopted in large towns, and even then there are practical difficulties which can be overcome only by the cordial and generous co-operation of the heads of large firms with the college authorities. Another excellent plan is that adopted in the school attached to the works of Messrs. Mather and Platt, at Manchester. The drawings made in the schools are of work actually in progress in the shops. One day the teacher gives the necessary explanations and calculations, and the next day the scholars see, as it were on the anvil, the very thing which has been the subject of his lecture. For the present it would seem (especially in small towns, where technical schools are for the most part only engaged in giving science teaching) that the chief part of secondary technical schooling should not precede but accompany work in the workshops. The apprentice can only be taught one sub-division of his trade in the workshop. It is to the technical college we must look to supplement this by a theoretical knowledge of all branches of the trade. It should not be forgotten that a good general education is the foundation of the special education for special avocations. A lad well trained to use his eyes and hands, his memory and common sense, has a good outfit for most ordinary employments. If he has further general accomplishments, they will in themselves be no hindrance, but often a great help. It has been noticed how quickly those who have enjoyed higher general education are able to acquire the technical details of particular trades. It is true that there are many kinds of work which can be done as efficiently by an uneducated as by an educated workman; and that the higher branches of education are of little direct use except to employers and foremen and a comparatively small number of artisans. But a good education confers great indirect benefits even on the ordinary workman. It stimulates his mental activity; it fosters in him a habit of wise inquisitiveness; it makes him more intelligent, more ready, more trustworthy in his ordinary work; it raises the tone of his life in working hours and out of working hours; it is thus an important means towards the production of material wealth. The wisdom of expending public and private funds in education is not to be measured by its direct fruits alone. It will be profitable, as a mere investment, to give the masses of the people much greater opportunities than they can generally avail themselves of. For by this means many, who would have died unknown, are enabled to get the start needed for bringing out their latent abilities. And the economic value of one great industrial genius

is sufficient to cover the expenses of the education of a whole town; for one new idea, such as Bessemer's chief invention, adds as much to England's productive power as the labour of a hundred thousand men.

Yours faithfully,

J. WOODHEAD.

DEAR MR. DUCKITT, 44, WEST GEORGE STREET, GLASGOW.

I thank my friend the author of this paper most cordially for giving me the pleasure of reading it, and the privilege of joining in the discussion. With the views set forth I am, generally, in entire agreement; whatever minor points upon which I feel inclined to join issue with him, being merely trivial compared with the major ones. A paper like this is well timed at the present, when we are being pressed on all hands by foreign competition, and when an active militant educational spirit is abroad. The author's remarks, it is true, have special reference to the training of young engineers, but if for "engineers" we read "chemists," "textile manufacturers," or any other trade or group of trades, the remarks are equally true and pregnant with suggestive meaning. "Suggestive" is, I believe, the term that best describes the scope of the paper. It is not meant to be exhaustive—indeed its title seems to disclaim all intention to be such—it is meant more to give a trend to one's ideas on the subject, to stimulate thought and inquiry, to invite elaboration from the minds and experiences of others. But, as I have already remarked, it comes at the right time. It was said of Khartoum Kitchener, the other day, that some one asked him what was the first thing he was going to do about our transport service in South Africa. "Are you," said the inquisitive one, "going to re-organize it?" "No," replied he (with what the newspapers described—if I remember rightly—as a sardonic smile), "I am going to organize it!" That, it seems to me is what is wanted with our whole "system of education"—if that can be called education which is merely instruction, and which has no system at all in its invertebrate being—organization. At present, it consists merely of a number of more or less disjointed units—*disjecta membra* the anatomists would call it—separate links, strong enough each may be in itself, but without the intimate union that would form them into a chain. Hitherto, as is ably shown in the paper, we have had far too much instruction—mere piling up and cramming in of facts—and far too little education, of "teaching children to teach themselves," of inculcating of principles and ideas. The system which has, up till quite recent times, been administered from Whitehall is altogether responsible for the methods of teaching that have led to such results. It has been urged over and over again, but with

very little effect, that such a system is far too bookish—appeals too much merely to the memory and too little to the senses and the reasoning faculties. A child is not being educated, in the real sense of the word, who is not taught to look for the reason behind the fact and from this to generalise within proper limits.

The first thing essential to be done then is to impress on our legislators the necessity of having a root idea which will govern a complete system of education from our primary schools to our universities; and after that to convince them of the paramount necessity of co-ordination amongst our various educational agencies, so that no one will overlap any other in the subjects treated, nor run counter to it in the methods adopted in treating them. It matters little what the root idea may be, only let them get some one idea to serve as a foundation and point of departure. I have so much faith in them as to believe that a real workable, living system would follow, such as would revolutionize our whole educational fabric.

Then it must be brought home to municipalities, as governing bodies and as representing large collective interests, that their well-being is bound up in such a thorough scheme of national enterprise, and that it is not merely a matter of eclecticism, but that it is actually and really one of bread and cheese!

With municipalities thoroughly interested it ought not to be a very difficult matter to convince our merchant princes (who, after all, are mostly benefited by the thorough and systematic training of their workpeople) that it is to their direct interests to put their (financial) shoulders to the (educational) wheel and see that it does not stick in the mud of neglect or postponement.

But all this is mere talk and unless something is done in the matter, nothing more fruitful than that most fruitless thing, an academic discussion, will ensue. It is certainly high time that something was being done to give us an educational system at least on a par with the best of our Continental neighbours, and there is no body by whom pressure could more justly or more actively be brought to bear than by your own or some other similar Institution. I believe the time is ripe, and that much good could be done by a powerful combination of the great institutes of the land—Mechanical, Civil, Engineering, Chemical, Electrical—in conjunction with the Chambers of Commerce of the various centres of trade. A word to the wise is—or ought to be—enough.

Yours faithfully,

T. Crichton Fulton.

The discussion was closed.

THE FOULING OF SHIPS.

By W. H. ATHERTON, B.Sc.

[Read before the Institution, in South Shields, on March 23, 1900.]

I.—The Nature of Fouling.

A clean, newly-painted ship, floating quietly in sea water in the the vicinity of land, soon has her bottom, if unprotected, seized upon as a suitable field for the growth of vegetable and animal life, so that, under conditions favourable to fouling, it becomes covered in a few months with a plentiful crop of grass, sea-weeds, barnacles,* mussels, and similar low forms of marine life. So great is the increase of skin resistance due to the presence of this fouling matter that a 12-knot ship is often reduced to an 8-knot ship, with a corresponding loss of time and waste of fuel. The subject of the fouling of ships and its prevention is therefore of very great practical importance. It is also rich in scientific interest, as it involves many instructive mechanical, chemical, electrical, and biological considerations.

The circumstances which promote fouling are the following:—

(1) Lying at anchor in shallow water. In all probability fouling seldom begins when the ship is in motion on the open sea; though, no doubt, the growth of vegetation and animals which have attached themselves while in harbour goes on continuously.

(2) Rough corroded surfaces foul more rapidly than smooth surfaces, so that if only for this reason it is wise to take every precaution against the corrosion of ships' bottoms. Even the smoothest bodies, such as glass bottles, will roughen and foul in course of time.

(3) High temperature is favourable to fouling. During the spring and summer months marine vegetation grows apace, but winter is a period of comparative inactivity. In the harbours of tropical climes, fouling goes on with special rapidity.

(4) The prevalence of the germs of fouling matter, owing to certain local peculiarities. The waters of the Dutch Indian archipelago, for

* See Note I. in the Appendix.

instance, have a very bad reputation. The ports of Java are prob the worst in the world. It has been stated that vessels lying at Sura for a week, at almost any time of the year, will get foul in spite of best composition ever invented, and that even the copper-bottomed s discharging or loading at this notorious port come home covered shells 4 inches to 6 inches long. The mail steamers running to Maur seldom return clean, although they dock and repaint three or four t a year. On the other hand, comparatively little fouling goes on at port of Calcutta, at the Chinese fresh-water ports, at the antipode the North Atlantic ports, and at the Baltic and European ports erally, excepting those on the Mediterranean.

Fouling apparently does not take place to any serious extent in and brackish waters: a fact which long ago led that pioneer of iron s building, Sir William Fairbairn,* to make the following suggestion :

The subject of fouling and the adhesion of barnacles to the hulls of iron v has been, since their first introduction, a source of trouble and of difficulty for no effectual remedy has been applied. On enquiry at Liverpool as to the eff fouling of iron vessels trading between that port and Calcutta, I was inform Captain Campbell, of the "Kenyon," that he had no trouble with his ship, a plates were left perfectly clean after being a short time in the fresh water o Hooghly. If this be the case, why not have docks or basins filled with fresh at the different ports, into which vessels covered with mollusca might be floate the purpose of cleansing and removing the obstructions to which they are su when built of iron? It is an easy mode of getting quit of the nuisance, and without injury to the plates.

II.—The Effect of Fouling.

The principal effect of the fouling of a ship is an enormous inc of the resistance experienced by the ship in its passage through water; causing loss of speed, and also in the case of a steamship, g waste of coal. By fouling, the coefficient of friction is quite comm doubled; and ships occasionally become so foul that the skin fri mounts up to four times its value for a clean bottom. A few progre speed trials of ships in various stages of foulness would be interesting.

In Fig. 1 the full curve shows the actual indicated horse-p at progressive speeds required to drive the United States cr "Yorktown." The dotted curve shows the calculated power require drive the ship when moderately foul, supposing the skin friction t doubled. The speed for a given power is then about two knots less before fouling.

* *Treatise on Iron Shipbuilding*, 1865.

The indirect effect of fouling on the speed should also be recognised. For a given referred mean pressure on the low-pressure piston the increased skin resistance causes a reduction of revolutions per minute;

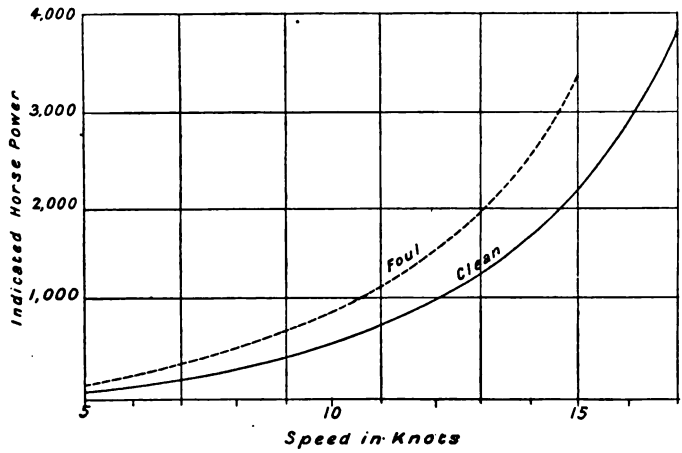


FIG. 1.

so that, unless a later cut-off in the high-pressure cylinder, or else a higher initial pressure can be given, the indicated horse-power will fall off along with the revolutions, just when all the available engine power is most needed.

A few figures will serve to give some idea of the waste of fuel due to fouling. Cases are on record where a few months in tropical waters have caused such an amount of fouling as reduced the speed of the ship by one-half. But take the more moderate case of a cargo boat, capable of steaming at 12 knots when clean, with 2,000 indicated horse-power at 80 revolutions per minute, and suppose she can do only 9 knots when foul. With the same referred mean pressure, the revolutions per minute corresponding to 9 knots will be about 60, and the power will be reduced to 1,500 indicated horse-power. Now, the power needed to drive the ship, when clean, at 9 knots would be only about

$$\left(\frac{9}{12}\right)^3 \times 2{,}000 = 844 \text{ indicated horse-power,}$$

assuming that the efficiency of propulsion is constant over the range of speed considered, and that the power varies as the cube of the speed. Hence the power wasted in overcoming the extra skin friction is $1{,}500 - 844 = 656$ indicated horse-power, which is no less than 44 per cent. of the power developed at the lower speed. Assuming a coal consumption of 1·5 lbs. per indicated horse-power per hour, the waste

of coal per day caused by fouling will be 24 × 1·5 × 656 lbs. = 23,616 lbs. = 10·55 tons, and per month 316 tons. With coal at the low price of 10s. a ton, this represents a loss of £185 per month for fuel alone. (The present price of Welsh steam coal is about 23s. per ton.) Of course, the delay caused by fouling and the increased wages to be paid per voyage are also important considerations.

III.—The Prevention of Fouling by Metal Sheathing.

The practice of sheathing ships is of great antiquity, relics of Roman ships having been found, it is said, covered with plates of lead and copper. For hundreds of years copper sheathing undoubtedly has been applied to wooden ships, in order to protect the timbers against the ravages of worms, and to preserve a clean bottom. Muntz or yellow metal, an alloy consisting of 3 parts of copper and 2 parts of zinc, has also been used with success. Zinc sheets have been tried on several ships, notably the Italian battleship "Italia," but have not proved a great success.

In the early days of iron ships great outcries were raised by their opponents because the bottoms fouled so rapidly. Accordingly copper sheathing was tried; but at first the remedy proved worse than the disease, for the immersion in salt water of iron and copper in metallic contact led to powerful galvanic action and the rapid destruction of the iron, as explained in Note II. of the Appendix. Before copper sheathing could be made a success, very careful insulation from the hull, in the shape of wood backing, was found to be absolutely necessary, and this meant great expense, as well as increased beam.

The present price of zinc sheets is about £30 per ton, and of copper sheets about three times as much. No doubt some member will be able to state the entire cost of sheathing, in the best manner, a cruiser of, say, 5,000 tons displacement.

For the protection of warships against fouling, no composition is equal to properly insulated copper sheathing. Accordingly, the chief constructor of the United States Navy (Rear-Admiral Hichborn) strongly urged, in his last annual report, the importance of sheathing all warships intended for distant service. As a result, the new U.S. battleships will be sheathed with copper. Further, six second-class cruisers recently ordered for the same navy will be sheathed with pine up to 30 inches above the water-line, and then coppered; the anti-fouling virtues of this method having been amply demonstrated during the late Spanish-

American war. Many Elswick cruisers for foreign powers are sheathed with wood and coppered.

In Fig. 2 is shown a method of insulating copper sheathing from an iron or steel hull. Each of the wrought iron bolts is screwed through the plating, and further secured by a hemp packing ring, steeped in red lead, a thin washer, and a nut. The head of each bolt also rests on a hemp packing ring (or "grummet"). The outer planking is secured to the inner by naval brass screws, $\frac{5}{8}$ inch diameter, packed in a similar manner. The surfaces of the planking in contact, also the outer surface, are well painted with a mixture of red and white lead. The edges are caulked with oakum. Lastly, sheets of tarred brown paper separate the copper sheathing from the planking, to which it is fastened by copper nails. Almost as much care is thus taken with the insulation as in the case of electrical machinery.

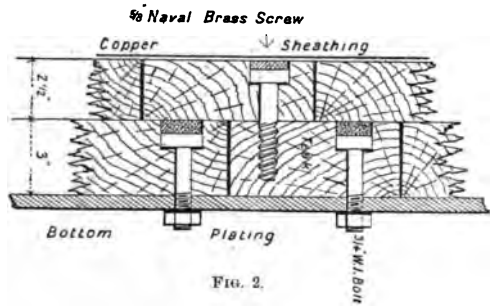


Fig. 2.

In spite of all these precautions, the insulation is not perfect, but the electrical resistance is sufficiently great to reduce the current to a harmless magnitude. In fact, in recent ships a single thickness of planking, well caulked and fastened with bolts, has been found sufficient. In ships thus sheathed there exists the danger that should any damage to the insulating material take place, as by grounding, the small exposed area of iron bottom plating and the large area of copper would together form a voltaic couple, with the inevitable result of rapid corrosion of the iron or steel plates. The American practice in the sheathing of warships is described in Note III. of the Appendix (page 175).

According to Sir W. H. White, a very large number of sheathed ships are now employed in the Royal Navy and in foreign navies. The extra cost and weight of the wood and copper sheathing and of the bronze stems, stern posts, and rudders must be regarded as the price paid for securing the maintenance of speed during long periods afloat, and the avoidance of frequent dockings and recoatings, such as are necessary in unsheathed ships.

A recent example is the U.S. cruiser "Denver," of 3,200 tons displacement, described in *Engineering*, January 12, 1900. The hull is sheathed with a single thickness of 4-inch Georgia pine, covered with

copper weighing from 28 oz. to 32 oz. per square foot. This represents a thickness of about $\frac{1}{20}$ inch.

Though copper is the best anti-fouler known, it is by no means perfect. A friend reports that when, many years ago, he used to dock and recopper the Tees floating lightship every three years he found it necessary to scrape off tons of mussels. Mr. H. van Meerten, late chief constructor of the Dutch navy, in a recent letter to the author, also says :—

> From time to time I have docked copper-sheathed ships badly fouled, without having discovered any apparent reason for this fouling. And, curiously enough, copper which has lost its anti-fouling properties seems not to be able to recover them. Copper once fouled, either by electro-negativing it with zinc, or through other unknown reasons, however well cleaned in dock, soon becomes again fouled. Some permanent setting of the molecules must be the cause of this strange circumstance.

From a theoretical point of view, zinc possesses great advantages over copper as an anti-fouling material—because zinc is electro-positive to iron, and therefore protects the latter from corrosion. Hence its use has been strongly advocated by many writers, and several modes of attaching zinc sheets to iron hulls have been devised. But in practice zinc sheathing has proved a failure. The fact is, when zinc and iron are in good metallic connection, the zinc is fairly effective as an anti-fouler so long as it lasts, but its life is short. On the other hand, when the two metals are *not* in close metallic connection, or are insulated, the zinc lasts a long time, but is very little use as an anti-fouler. It has also been found that zinc becomes so rough, after a short period of service, as to increase the skin resistance of the ship very materially. Other objections to zinc sheathing are that it wastes away in a very uneven fashion, and that it becomes so brittle after no great service as to break off in patches.

The cause of the anti-fouling properties of metallic sheathing is a decidedly vexed question, upon which doctors disagree greatly. Three theories are current, namely :—

1. The mechanical, or exfoliation* theory, *i.e.*, the scaling off in thin layers of small portions of chemically altered sheathing.
2. The chemical, or dissolving theory; which is often confused with the first theory.
3. The biological, or poisoning theory.

* Latin *ex*, off, and *folium*, a leaf: hence, "to come off in scales." The term exfoliation is often used as if merely synonymous with "wasting away."

These may also be respectively styled the scaling off, the washing off, and the killing off theories of anti-fouling.

(1) Thus, at a meeting of the Institution of Naval Architects in 1866, Sir John Hay said :—

There is a sort of belief that one of the advantages of copper consists in the fact that the verdigris destroys the marine animal or vegetable substance which attaches itself to the ship's bottom ; but the fact is that the action of copper in keeping a ship clean is mechanical. We find that copper oxidises in parallel layers, and that it sheds off in very thin layers, so that the substances which cause the fouling of the ship lose their hold, and are detached by the continual exfoliation of the copper.

(2) Mr. H. van Meerten, who has given much attention to the subject, says :—

Of all the theories current upon the exfoliation of copper and its alloys, that of Sir Humphry Davy is the only true one. According to this, the exfoliation of copper is the consequence of the formation of a slightly soluble oxychloride of copper. Barnacles cannot, therefore, adhere firmly to the metallic copper; for, between their scales and the metallic copper, the oxychloride is continually formed by the presence of ordinary salt (NaCl) and the oxygen contained in sea water, and through its solubility it is washed away.

Sir W. H. White gives a similar explanation, and then adds, "Some chemists have ascribed importance to the poisonous character of the salts of copper in preventing fouling ; but the foregoing is undoubtedly the more important feature." Professor V. B. Lewes* also, in the main, expresses similar views.

(3) In opposition to the above views, Mr. M. Holzapfel, in a paper read before the British Association at Newcastle-upon-Tyne in 1889, said :—"When copper exfoliates it produces a poison (oxychloride of copper) which is highly destructive to the lower animal and vegetable life, and this poison is the active anti-fouler, which kills the fouling matter before it can attach itself."

It is well to note that there are several oxychlorides of copper, differing slightly in composition. The green oxychloride has the formula $CuCl_2\ 3\ CuO + 4\ H_2O$. It is probably formed by the following reaction :— $2\ NaCl + 4\ H_2O + 2O_2 + CO_2 + 2\ Cu_2 = CuCl_2\ 3\ CuO\ H_2O + Na_2\ CO_3$.

Copper Powder and Electro-coppering. Copper powder is used as an anti-fouler on small wooden yachts and canoes, and answers the purpose very well. But of course copper powder would be quite out of place on a steel ship, owing to galvanic action. Metallic copper is sometimes

* *Trans. Inst. Naval Architects*, 1889.

introduced into anti-fouling compositions, to the great injury of the ship's plates.

A few years ago a syndicate was started in the United States to deposit copper electrolytically on the bottoms of steel ships. As it was not practicable to fill the entire dry dock with copper in solution, coffer dams were constructed to fit various sections of the ship and filled with the electrolyte. In this way the entire bottom could be covered with a deposit of copper. The syndicate bought a tug, to which they applied the system, after carefully cleaning the bottom. Two years afterwards the bottom was found to be in such a damaged condition, owing to galvanic action, that the system of electro-coppering was pronounced a failure. In spite of this experience the following paragraph, which members are invited to criticise, recently appeared in several papers :—

After trials lasting four years, a favourable report has been made to the United States Government on Crane's system of copper-plating the hulls of ships in order to prevent fouling by marine growths. The whole bottom of a ship, 400 feet long and drawing 20 feet of water, can be plated in eight or nine days with a thickness of copper of one-sixteenth inch or more. Some 55,000 lbs. of copper would be required for a vessel of that size. On the other hand, £4,000 a year is expended by some trans-Atlantic boats in overcoming the resistance due to fouling, and to this must be added the cost of docking for cleansing the bottom.

IV.—The Prevention of Fouling by Compositions.

The costliness of copper sheathing has resulted in its omission in by far the greater number of ships afloat, not excluding the finest Atlantic liners, and the use, as a cheap substitute, of a special anti-fouling paint or composition, which is laid over one or two coatings of an anti-corrosive (or protective) paint. Such ships are docked once or twice a year for a general inspection of the bottom and for cleaning and repainting the same. The price for docking a vessel of about 4,000 tons deadweight in the dry dock of one shipbuilding yard is about £20. This sum includes shoring, pumping out the dock, laying on two coats of composition, which is supplied by the owners, and undocking. The price stated, however, is hardly a paying one, the work being undertaken in the hope of it leading to other business in the way of repairs.

High priced patent compositions dry much more rapidly than the ordinary red oxide of iron paint. This property of quick drying is a distinct advantage, owing to the time and dock dues thereby saved.

The requirements of a satisfactory anti-fouling composition are the following :—

1. It should not be excessively expensive.
2. It must dry quickly.
3. It must stick on well.
4. It should have a hard, smooth surface when dry.
5. When properly applied, it must not act injuriously on the ship's plates.
6. It must prevent serious fouling for from nine to twelve months.

It is no part of the duty of an anti-fouling composition to preserve the plates from rusting. That is the function of the preparatory protective coatings, consisting of either a slow-drying oil paint or a quick-drying varnish paint.

Anti-fouling paints, for the most part, are divisible into two classes :—

(*a*) *Grease paints*, which consist of either tallow or soap, mixed with compounds of copper, zinc, or lead. Zinc white (ZnO) and tallow is a well-known mixture which has been much used. Such mixtures have the disadvantage of requiring to be heated before application, and the surface produced is neither hard nor very smooth. Hence the coating is not durable, and the skin resistance of the ship is considerable.

(*b*) *Varnish paints*, which consist of a solution of gum, of shellac, or resin in spirits of wine, naphtha, or other solvent, to which has been added a strong colouring matter (or pigment) and a salt of copper, zinc, arsenic, or, best of all, mercury—the whole being thoroughly mixed together. It is the object of the composition manufacturer to combine the poisonous salts with a varnish sufficiently soluble to admit of these salts being slowly acted upon by sea water for a period of about twelve months. Copper sulphide (CuS) and mercuric chloride ($HgCl_2$) appear to be the principal salts used.

An unclassed paint, much used in the home trades, consists of black varnish covered with a coat of shellac mixed with beer. Hundreds of patents have been taken out for all sorts of anti-fouling compositions, many of them quite useless. One patent composition of the better class consists of linseed oil, corrosive sublimate ($HgCl_2$), litharge (PbO), red lead (Pb_3O_4), bitumen, pitch, and sufficient turpentine to form a workable paint. The mercuric chloride is extremely poisonous. Another specification gives orange shellac, white and red lead, vegetable pitch, marine driers, linseed oil, and turpentine. A recent patent specifies a mixture of resin, varnish, and alum, together with a pigment, such as Indian red, and a naphtha drier. Arsenical and phosphoric soaps also have been used, on account of their poisonous properties.

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(*b*) *Varnish paints*, which consist of a solution of gum, of shellac, or resin in spirits of wine, naphtha, or other solvent, to which has been added a strong colouring matter (or pigment) and a salt of copper, zinc, arsenic, or, best of all, mercury—the whole being thoroughly mixed together. It is the object of the composition manufacturer to combine the poisonous salts with a varnish sufficiently soluble to admit of these salts being slowly acted upon by sea water for a period of about twelve months. Copper sulphide (CuS) and mercuric chloride ($HgCl_2$) appear to be the principal salts used.

An unclassed paint, much used in the home trades, consists of black varnish covered with a coat of shellac mixed with beer. Hundreds of patents have been taken out for all sorts of anti-fouling compositions, many of them quite useless. One patent composition of the better class consists of linseed oil, corrosive sublimate ($HgCl_2$), litharge (PbO), red lead (Pb_3O_4), bitumen, pitch, and sufficient turpentine to form a workable paint. The mercuric chloride is extremely poisonous. Another specification gives orange shellac, white and red lead, vegetable pitch, marine driers, linseed oil, and turpentine. A recent patent specifies a mixture of resin, varnish, and alum, together with a pigment, such as Indian red, and a naphtha drier. Arsenical and phosphoric soaps also have been used, on account of their poisonous properties.

introduced into anti-fouling compositions, to the great injury of the ship's plates.

A few years ago a syndicate was started in the United States to deposit copper electrolytically on the bottoms of steel ships. As it was not practicable to fill the entire dry dock with copper in solution, coffer dams were constructed to fit various sections of the ship and filled with the electrolyte. In this way the entire bottom could be covered with a deposit of copper. The syndicate bought a tug, to which they applied the system, after carefully cleaning the bottom. Two years afterwards the bottom was found to be in such a damaged condition, owing to galvanic action, that the system of electro-coppering was pronounced a failure. In spite of this experience the following paragraph, which members are invited to criticise, recently appeared in several papers :—

After trials lasting four years, a favourable report has been made to the United States Government on Crane's system of copper-plating the hulls of ships in order to prevent fouling by marine growths. The whole bottom of a ship, 400 feet long and drawing 20 feet of water, can be plated in eight or nine days with a thickness of copper of one-sixteenth inch or more. Some 55,000 lbs. of copper would be required for a vessel of that size. On the other hand, £4,000 a year is expended by some trans-Atlantic boats in overcoming the resistance due to fouling, and to this must be added the cost of docking for cleansing the bottom.

IV.—The Prevention of Fouling by Compositions.

The costliness of copper sheathing has resulted in its omission in by far the greater number of ships afloat, not excluding the finest Atlantic liners, and the use, as a cheap substitute, of a special anti-fouling paint or composition, which is laid over one or two coatings of an anti-corrosive (or protective) paint. Such ships are docked once or twice a year for a general inspection of the bottom and for cleaning and repainting the same. The price for docking a vessel of about 4,000 tons deadweight in the dry dock of one shipbuilding yard is about £20. This sum includes shoring, pumping out the dock, laying on two coats of composition, which is supplied by the owners, and undocking. The price stated, however, is hardly a paying one, the work being undertaken in the hope of it leading to other business in the way of repairs.

High priced patent compositions dry much more rapidly than the ordinary red oxide of iron paint. This property of quick drying is a distinct advantage, owing to the time and dock dues thereby saved.

The requirements of a satisfactory anti-fouling composition are the following :—

1. It should not be excessively expensive.
2. It must dry quickly.
3. It must stick on well.
4. It should have a hard, smooth surface when dry.
5. When properly applied, it must not act injuriously on the ship's plates.
6. It must prevent serious fouling for from nine to twelve months.

It is no part of the duty of an anti-fouling composition to preserve the plates from rusting. That is the function of the preparatory protective coatings, consisting of either a slow-drying oil paint or a quick-drying varnish paint.

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With regard to the mode of action of anti-fouling compositions great difference of opinion prevails. Prof. Lewes* says :—

In most compositions in use, attempts have been made to combine strongly poisonous substances with exfoliating and wasting coatings. . . . The presence of these substances probably exerts no deterrent action upon the fouling, save perhaps when the vessel is at rest. But they exert an important influence on the rate of exfoliation. For when the perishing of the varnish exposes them, they dissolve, or are washed out, and in this way tend to disintegrate and clear away the surface more rapidly—an important function, but one which might be more cheaply performed by substances other than high-priced metallic poisons.

A firm of manufacturers of ship-compositions says :—"The action of our anti-fouling composition is a combination of poisoning and slowly dissolving."

Another firm says :—

Our compositions act in the main by poisoning. The poisons contained in them undergo a chemical action in contact with salt water, and a poisonous zone surrounds the surface of the vessel, which prevents the germs of animalculæ or grass from attaching themselves to the surface. Of course the poisons require to be freed, and so far only as the compositions must allow the poisons to be gradually freed in salt water do the compositions act by exfoliation or dissolving as well, but not in the ordinary acceptation of the term exfoliation.

The term *exfoliation*, in reference to anti-fouling compositions, is understood to mean the separating of small particles of composition from the main body, so that any animal or vegetable growth which may have become attached to the bottom of the vessel, is caused to drop off.

The precautions necessary to be observed for efficiently coating a ship are the following :—

(1) The ship's plates must be quite dry, not sweating, when the first protective coat is applied.

(2) All unsound old paint and rust must be scraped off.

(3) In the case of new ships two coats of priming (or protective paint) must be applied and allowed to dry. In subsequent dockings, it may suffice, in many cases, to simply "touch up" the bad parts with the priming.

(4) The anti-fouling composition must be kept well stirred to prevent the metallic salts from separating out, and applied uniformly over the entire bottom, in one coat.

The common method of buying ships' compositions on faith seems to be rather unscientific. To an outsider it would appear much more rational for shipowners to first ascertain by experiment what mixture of well-known anti-fouling substances best meets their requirements, and then

* *Trans. Inst. Naval Architects*, 1889.

to call for tenders in the open market to their own specification ; making sure, by chemical analysis, that they get what is specified.

On this point a very sensible article in the *Shipping World* says :—

The time is, perhaps, not far distant when anti-fouling compositions will become a general staple trade article, sold according to analysis, the same as soda, potash, and other chemicals. At present there is much prejudice in respect of brands, as well as general ignorance of the subject amongst consumers. They may pay a high price to one firm for the identical article which is offered to them by another firm at a much lower price. By analysing the various articles submitted to them, shipowners might save thousands of pounds per annum in their composition account.

Before any substantial advance can be made in the prevention of fouling, a searching investigation is required into the entire subject from all points of view—the biological, the chemical, and the physical. Such an investigation might well be undertaken by a special commission or committee, including amongst its members experts in each of the departments of knowledge involved. Probably no one man is fully qualified for such a task.

In conclusion, the author wishes it to be understood that his interest in the present subject is purely scientific, being himself in no way connected with the manufacture, sale, or use of any anti-fouling material. He has tried to treat the subject impartially, and with the sole aim of arriving at correct views. It is hoped that members possessing personal knowledge of the value or otherwise of particular compositions and modes of sheathing will not be slow to express their opinions and experiences, in order to assist in the formation of definite conclusions.

For various interesting items of information, freely given, the author desires to express his indebtedness to Mr. H. van Meerten, M.I.N.A., Mr. M. Holzapfel, Messrs. Ripolin, and Mr. A. L. Mellanby, M.Sc.

APPENDIX.

Note I.—The Natural History of Barnacles.

The common barnacle belongs to an order of crustacea, the species of which are characterised by curled jointed feet. For this reason the order is styled "Cirripedia," a term derived from the Latin *cirrus*, a curl, and *pes*, *pedis*, a foot. Consequently, barnacles are allied to crabs and lobsters, though very unlike them in external appearance.

In their infancy, barnacles are free-swimming little creatures, resembling minute shrimps; but, unless they perish, they early attach themselves to some solid object, such as a rock, a log of timber, or the bottom of a ship. When in this fixed condition the internal organs are protected by a calcareous shell, composed of many pieces. The only parts of the animal remaining movable are the legs, which are continually employed in searching for food. The anterior part of the body forms a kind of long stalk, by which the animal anchors itself to any convenient object. Fig. 3, taken from Dr. H. A. Nicholson's *Zoology*, shows two fully-grown specimens of the common barnacle, growing upon a foreign body. S is the stalk of attachment, and B the body of the animal, enclosed in a shell, from which the legs can be protruded.

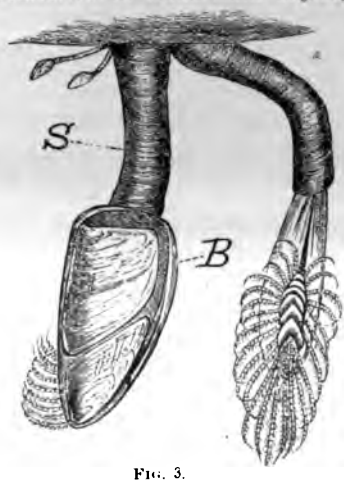

Fig. 3.

The acorn barnacle, or Balanus, has no stalk. The head is fixed to the centre of a shelly plate, and the body is protected by a shell built up of several pieces, and having an opening at its summit. This opening is closed by a movable lid, and from it the legs are protruded in quest of food. This is the animal that is so commonly found growing in clusters on rocks below high-water mark, as well as on ships' bottoms. Though fixed when an adult, it swims about when immature. Fig. 4 shows a group of stalkless barnacles.

In the Manchester Museum, Owens College, there is a large specimen of the common stalked barnacle (*Lepas Nillii*), fully 15 inches long, the stalk tapering from $\frac{3}{4}$ inch thick at the fixed end to $\frac{3}{8}$ inch at its junction with the shell. The latter, which is flattened and segmented,

FIG. 4.

measures about $1\frac{1}{2}$ inches by 1 inch. The museum also contains a curious piece of whale's skin, to which are firmly attached several large acorn barnacles, these in their turn carrying a heavy burden of stalked barnacles.

It is said that barnacles inhabit shallow waters only, and that, when once detached from their anchorage, they cannot again attach themselves to a solid body, but perish. It is probable, also, that infantile barnacles are susceptible to metallic poisons, and adult barnacles not so. A point on which information is solicited is the nature of the animal's food and its method of feeding; also its likes and dislikes. Possibly, metallic poisons have the effect of killing, or else scaring away, the food of barnacles. But the whole question of the life-history and habits of barnacles needs thoroughly investigating. One very important fact has been made out, viz., that barnacles are hermaphrodites, or self-multiplying animals.

It is conceivable that some unobjectionable form of life, capable of preying upon fouling matter in the early stages of its growth, might somehow be cultivated on ships' bottoms; in imitation of the bacteriological method of sewage purification.

NOTE II.—ELECTRO-CHEMICAL OR GALVANIC ACTION.

(1) When a strip of *zinc* is placed in a glass vessel containing water slightly acidulated with sulphuric acid, chemical action goes on.

Bubbles of gas (H) collect on the zinc and rise to the surface of the liquid. The zinc also wastes away, *i.e.*, passes into solution in the form of a salt of zinc. The chemical reaction is expressed by the equation

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$

On repeating this experiment with a strip of *iron*, a similar action takes place, hydrogen being evolved and the iron slowly dissolved, but the action is not quite so vigorous as before. The chemical reaction is expressed by the analogous equation

$$Fe + H_2SO_4 = FeSO_4 + H_2.$$

Trying the same experiment with *copper*, no action can be observed. Thus there is a gradation in the chemical activity of zinc, iron, and copper.

(2) When a plate of pure or amalgamated *zinc* and a plate of *iron* are together placed in a slightly acid bath and allowed to touch each other outside of the liquid, a vigorous action is seen to proceed. Hydrogen is given off at the *iron* plate, and the zinc rapidly wastes away. As soon as the plates are separated the action ceases, or nearly so. This is the simplest case of galvanic action.

On repeating the experiment with *iron* and *copper*, a similar action goes on; but the gas is given off from the *copper* plate, while the iron now wastes away, and is deposited on the copper. Thus, compared with the iron-zinc couple, there is a distinct reversal of effect.

(3) If we attach a copper wire to the unimmersed parts of both the zinc and iron plates, bubbles of hydrogen escape from the *iron* plate, and the zinc wastes away. Further, the connecting wire has the power of deflecting a magnetised needle placed near to and parallel with it.

On repeating this experiment with an iron-copper couple, the deflection of the needle is seen to be in the opposite direction. The effect described is best observed by the aid of a galvanometer.

If we substitute, for the dilute acid, a saline solution, as sea-water, the action is similar in kind, but feebler in intensity.

(4) We are thus led to conclude that, when two metals differing in chemical activity are immersed in a conducting liquid and connected by a conductor outside of the liquid, a current of electricity is established, the direction of which depends on the relative ease of solution of the two metals. Conventionally speaking, the current starts within the liquid at the surface of that metal which is the more readily dissolved, and which is termed the electro-positive element, passes through the exciting liquid, and leaves the cell by the receiving or electro-negative element. After traversing the outer circuit, the current re-enters the liquid by the electro-positive plate.

Berzelius has arranged the elements in a series, beginning with the most electro-positive and ending with the most electro-negative element. From this electro-chemical series the following selection has been made:—

+ Sodium.	Copper.
Magnesium.	Mercury.
Aluminium.	Silver.
Zinc.	Platinum.
Iron.	Carbon.
Lead.	— Sulphur.
Tin.	

Th farther apart in this series the elements of a voltaic couple are separated, the higher is the electro-motive force of the resulting current for a given liquid. Hence the list is sometimes referred to as the electro-motive series. It will be noticed that zinc is feebly electro-positive to iron, while copper is moderately electro-negative to iron.

Note III.—Mode of Attaching Copper Sheathing.

According to Chief Constructor Hichborn,*

The latest practice for sheathing is to use a plank of teak worked in 12-in ch strakes, sufficiently thick to give a good caulking seam, or from 3½ inches to 4 inches finished. The bolts are of naval brass, ¾ inch in the shank, reduced to 11/16 inch over the thread, the heads being 1½ inches diameter and sunk a sufficient depth to be from ⅝ inch to ¾ inch below the surface when finished, and being well set up so as to compress the wood under the heads ⅛ inch. A nut is fitted on the end, bearing on a thin iron washer; and after being finally hove up, the thread is centre-punched to check it. Hempen grummets, saturated with a mixture of red and white lead, are carefully fitted both under the washer and head of each bolt, and the recess over the head is filled with Portland cement. The bolts are spaced with about 15 inches pitch, except at the butts, each butt having four bolts. After the fastening is completed, in order to fill up, as far as possible, all spaces that may exist between the plank and the skin, holes are bored in the centre of each strake of plank about 6 feet apart, and a composition of red and white lead is pumped in under pressure until it comes out at the adjoining holes, care being taken to so limit the pressure that it will not injuriously strain the fastening. After this has been done the holes are carefully plugged.

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* "Experience Gained with New Steel Ships as regards Care and Preservation:" a paper read in 1894 at a meeting of the American Society of Naval Architects and Marine Engineers. See also a recent paper by the same writer on "The Sheathing of the U.S. cruiser 'Chesapeake,'" and reprinted in *Engineering*, December, 1899.

DISCUSSION.

Mr. S. J. P. Thearle in opening the discussion at the Chairman's request, said that he had already spoken twice that evening, but as he would not have many more opportunities of being in their midst he trusted they would excuse him for again occupying their attention.

The subject of anti-corrosive and anti-fouling paints had, necessarily, often come under his notice as a Lloyd's Surveyor, and he had taken much interest in watching the results obtained with different mixtures. But before speaking upon this part of the paper he desired to offer a few remarks regarding what Mr. Atherton had said with reference to the fitting of metallic sheathing upon the bottoms of wooden ships. Mr. Atherton says that "for hundreds of years copper sheathing had undoubtedly been applied to wooden ships in order to protect them from the ravages of worms and to preserve a clean bottom." In this he thought Mr. Atherton was mistaken. Certainly it had not been used in the Royal Navy for more than about a century, and he felt sure that the navy of this country and the mercantile marine also would be at least as well provided in this respect as the ships of other powers. So far as his memory served him it was to Sir Humphry Davy that the Admiralty owed the first suggestion for the use of copper sheathing on ships for protective and anti-fouling purpose.

Then again, with regard to the constituents of Muntz metal sheathing, he thought it would be found that these were 67 of copper to 33 of zinc; that is to say, 4 of copper to 2 of zinc, and not 3 to 2 as supposed by Mr. Atherton. With reference to the difficulty experienced in composite vessels as regards the insulation of the copper sheathing on the outside from the iron work on the inside of the vessel, he might mention some cases of composite sailing ships which were built about thirty years ago at Sunderland, in which the shipbuilder very reasonably proposed to substitute short galvanized iron screw bolts for securing the wood keel to the flat keel plate in lieu of using through copper or yellow metal bolts as commonly adopted. This arrangement was approved by Lloyds' Committee as it was felt that such bolts would be safe from any galvanic action from the copper sheathing. It was found, however, that after about eight years these galvanized iron bolts were wasted away and useless, having apparently been brought into galvanic action with the copper sheathing through the wood keel being saturated with sea water.

The cases of these vessels serve to illustrate how difficult it is to properly insulate the copper sheathing, on iron, steel or composite ships, from the iron and steel materials of the vessel.

The writer of the paper discusses the question of whether the protection afforded by copper sheathing is due to exfoliation or poisoning. He (Mr. Thearle) held strongly that exfoliation was the true explanation, and in support of his contention he would instance cases in which plates of lead had been nailed to copper sheathed ships' bottoms with a view to arresting the chemical wear and tear of the sheathing, and therefore make it more durable. The usual life of ordinary yellow metal or copper sheathing is about four to six years, and by that time it is generally found to be wasted so thin as to require renewal. When the lead sheets were applied it was discovered that the durability of the copper sheathing was obtained at the cost of its anti-fouling qualities. The copper lasted much longer, but the vessels' bottoms were as dirty as if they had never been sheathed at all. Hence he (Mr. Thearle) reasoned that, as the copper was no less poisonous than before, it was by arresting the exfoliation that the sheathing had ceased to fulfil the duty expected of it.

Reference had been made to the plan proposed for the protection from fouling of the bottoms of iron and steel vessels by electro plating with copper. A few years ago the Messrs. Denny, of Dumbarton, who are noted for their liberal enterprise in such matters, were induced by an inventor to electro-plate the bottom of their steam tender—the "Snark" (a little vessel well known to the Chairman)—with copper in this way. The inventor of the process took the job in hand, and after carefully removing all oxidation from the bottom with the aid of a sand-blast, short sectional copper dams were fitted and secured to the bottom, and within the space so enclosed the electro-plating process was applied, the current being obtained by means of a small steam engine. When that section was done the apparatus was removed to another, and so on, until all the surface was covered with a sufficiently thick coating of copper. A few months trial was given to the vessel, and then she was taken out of the water and examined. The condition of the shell-plating was found to be so unsatisfactory that the whole of the copper coating was at once removed.

Mr. Atherton's reference to the various constituents of which the quick drying compositions were made reminded him (Mr. Thearle) that upon one occasion he saw a composition being used on a ship's bottom containing a large proportion of fusel oil, which, as is well-known, is a waste product of distilleries in Scotland and very plentiful. It dries very

rapidly, but it not only dried the paint on this vessel, but dried the painters also; so much so that they could not resist the seductive smell, but adjourned to an adjacent spirit shop, and would not return to the job.

What is particularly wanted at the present day is a composition which will protect steel and iron deck plating from wasting through the action of sea water upon it. The composition should be such that it would stand the wear due to treading upon it, and at the same time stop the rusting which now goes on at such a rapid rate. He knew cases in which steel decks were worn thin in eight or nine years, and those present were doubtless only too well acquainted with such cases. This is now become a very serious question to shipowners who would require to sheathe these decks with wood if means were not found for arresting the rapid deterioration.

Referring to the general question of how best to prevent corrosion of of the shell-plating in iron and steel vessels, he would remind the meeting of the phenomenon frequently witnessed in dry docks when vessels were prepared for being re-coated after a first or second voyage. As was well known it is a common experience to find the surface of the plates perfectly free from rust at the places where numbers and letters had been painted on them by the manufacturers in accordance with the identification particulars furnished by the shipbuilders. These marks were made with linseed oil paint soon after the plates left the rolls, and while still hot. It seems that the oil penetrated the substance of the plate when in a heated condition, and so protected it from the rusting influence of moisture. Is it not possible to usefully utilise this experience in dealing with the question of how to prevent corrosion in iron and steel ships?

In conclusion, he desired to thank Mr. Atherton for his valuable and suggestive paper, and to express the hope that the discussion upon it would not degenerate into an advertisement of the productions of rival manufacturers.

Mr. S. E. Hurndall said he did not like to speak about anti-fouling compositions because he was connected with it from a business point of view; still he should like to remark upon the paper as he disagreed with one or two things, whilst he agreed with most of the others. The statement about a foul vessel going into fresh waters and losing all the barnacles which she might then possess was an old-fashioned idea with little in it. True, in fresh water the barnacles would die; but they had fastened themselves with prongs or roots to the ship's bottom and would not necessarily fall off. He had been in connection with the anti-foul-

ing business for sixteen years, and had seen a thousand or so steamers docked in London, Liverpool, the Tyne, and elsewhere, and from his experience he must say the idea that a vessel could only keep clear for a very short time in very foul waters, was another mistake. It depended entirely upon the quality of the composition. There were paints and paints, some were cheap, others expensive, but he held it was with a composition of this kind as in other things, that the dearest at first was the cheapest in the end. From his own experience he believed the best way to treat a new steel vessel was to launch her without any paint whatever being applied. Allow her to remain in the water two or three months while she was being fitted out—the atmosphere would then be working on the upper part of the vessel and the water upon the lower part. Then dry dock her, thoroughly scrape and steel broom her, this would remove the mill scale or "bloom," the pores of the metal would then be open to receive the paint which should then be applied. To his mind a coat of zinc was the best to be applied first, and when thoroughly dry apply three coats of composition of good manufacture, and then it would always stand. If they started painting a vessel as soon as she was constructed, with a sound body of paint, they would find when that vessel had done her first voyage she had thrown a great deal of that paint off, and the surface would be very rough indeed, so much so, that it would take them all their time to put the ship right. A vessel built on the Tyne some months ago, was painted with oil paint on the stocks and went an Indian voyage. When she came back, from the light line to the bilge, that vessel was very much pitted. She was only four and a half months afloat. She had to be cleaned thoroughly, steel broomed, scraped, and above all, cemented. The condition of the bottom was, in his opinion, due to the painting of the vessel immediately she was built, and stopping every chance of the bloom coming away. The secret of the thing in his opinion was, let them rust, never be afraid of the appearance, put them into dry dock, and from the top of the rails to the keel give them three or four coats of good paint : by adopting such a process he was of opinion that the serious corrosion would be overcome which exists upon so many steel vessels of the present day.

Mr. C. Rennoldson said it was a question whether the thin scale should be taken off. He had seen a ship clean scraped after being sailing in English waters for twenty years and the bloom was on the plates just as they had come from the mill. There had been no

"fusel oil" used about it, only coated with composition and the mill scale preserved. It was a question whether the best preservative was not a complete, impervious mill scale. If they could get a paint that would preserve that they would have no pitting. With the scale on nothing could get beneath the surface, but the idea seemed now to get it off. Of course they got a great deal of it broken in punching and shearing; but so far as it was left and they painted it with a pure white lead the bloom would be there for years: that was his experience.

Mr. Thos. Whitfield said he had had some little experience with anti-fouling compositions. He spent months over an anti-fouling paint and spent pounds in trying to get it tried. He got a chance. Unfortunately it had to be used on a vessel in another dock than his own. The ship arrived on a Saturday afternoon and had to be away again on Monday morning. On the Sunday they conveyed the paint to the dry dock; but in lowering down their huge canisters of mixture the wretched chains broke and down went their anti-fouler to the bottom of the dock. They made a raid on all the paint shops in the vicinity, got what arsenic and mercury they could from the druggist store, but they could not procure the "secret" stuff for the re-make of their anti-fouler. Still they did their best without it, and the ship sailed. She made two voyages to the Mediterranean, after which the owners of the vessel came to him, shook him by the hand, and said, "Whitfield, you have solved the problem!" He considered the great mistake made with regard to all anti-fouling compositions was this: sufficient time was not given in the dry dock for justice to be done to the vessels. Before a vessel was dry she had to be taken out of dock again, so it meant throwing the paint on and running the water in at about the same time, and this did not give the paint a fair chance. They (the paint manufacturers) would do their best to protect the property of the owners, but they should have more consideration at the hands of the owners.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

SEVENTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, MARCH 30TH, 1900.

SUMMERS HUNTER, ESQ., VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in South Shields, on Friday, March 23rd, which were approved by the members present, and signed by the Vice-President.

Mr. D. B. MORISON read a paper on "The Naval Engineer: his Present Position and Influence on our Sea Power."

THE BRITISH NAVAL ENGINEER: HIS PRESENT POSITION AND INFLUENCE ON OUR SEA POWER.

By D. B. MORISON, Vice-President.

Read before the Institution in Newcastle-upon-Tyne, on March 30th, 1900.

INTRODUCTION.

In these days, when the necessity for the predominance of British sea power is accepted as an axiom of our Imperial existence, no introductory explanation need be offered for bringing before an Institution of Marine Engineers and Naval Architects an Engineering question having a direct bearing upon our naval supremacy.

Sea power is the resultant of many diverse factors, each one of which demands some special knowledge and experience for its correct comprehension, and it is the object of this paper to draw the attention not only of the members of this Institution, but of the engineering professions generally, to the present position of one vitally important element of sea power, the full significance of which they, by virtue of their special training and experience, are well qualified to understand and appreciate.

The strategical, tactical, and combative powers and functions of a ship of war are conceived, defined, and executed by the administrative and executive officers of the Royal Navy, but the responsibility for its creation, in the constructional sense, in accordance with the stipulated requirements, and for its ability during its active life to respond readily and effectively to the directing will of its commander, may be correctly said to devolve upon the engineering profession.

It is the engineer who designs and constructs the entire machinery of a warship. It is the engineer who is responsible for the generation of the all-essential steam, and for the vast aggregation of complicated machinery for its varied utilization, and again it is the engineer who is responsible for the maintenance of the mechanism of the entire armament in a state of efficiency.

A modern battleship is the very embodiment of engineering constructive science in its highest form, and steam is the source from which its every organ derives its vitality and utility, without which the entire costly creation becomes a mere inert mass, impotent for either effective attack or defence.

The Growth of Engineering in the Navy.

The following figures afford striking evidence of the enormous and rapid growth of our steam navy, and of the growth in numbers and in relative importance of the engineering branch of the service.

In 1863 the British Navy possessed only 3 ironclads, and the ships were still chiefly dependent upon sails for their propulsion.

At the end of 1882 there were about 55 ironclads ready for sea duty, and in 1888 there were 139 sea-going steam vessels in commission.

At the present time there are over 500 steam vessels in the Royal Navy, exclusive of harbour service and other small boats, and there are no less than 258 sea-going ships in commission.

In 1898, 30 vessels were launched, having an aggregate displacement of 140,988 tons, and a total of 253,600 I.H.P.

In 1899, 19 vessels were launched having an aggregate displacement of 122,322 tons and a total of 196,400 I.H.P.

At the end of 1899, 45 vessels were building, comprising 13 battleships, 14 armoured cruisers, and 18 smaller craft, including 12 destroyers.

Extract from a Parliamentary Return of Numbers of Commissioned Officers, Subordinate and Warrant Officers, Men and Boys of the Engineer Branch, borne on the 1st Day of April, 1858, 1868, 1878, 1888, and 1898 respectively, excluding Pensioners and Reserves.

	Commissioned Officers.	Subordinate Officers, *i.e.*, Engineer Students.	Warrant Officers.	Chief and other Engine Room Artificers.	Stokers.		Total.
					Petty Officers.	Men.	
April 1, 1858	971	...	...	...	2,880		3,851
April 1, 1868	1,128	...	...	...	881	3,382	5,391
April 1, 1878	809	...	...	571	850	3,397	5,627
April 1, 1888	662	...		1,163	1,384	5,327	8,536
April 1, 1898	845	196*	16	2,498	3,853	14,881	22,289

* Engineer students were not included in the numbers voted for the fleet before 1889.

For 1899-1900 the numbers were as follows :—

Commissioned officers	910
Chief and other engine-room artificers	3,024
Stoker ratings	21,472
Making a total engineering personnel of	25,406

The undermentioned figures will serve to indicate the relative rates of increase of the executive and engineering branches :—

	1878	1898
Executive personnel	27,911	44,336
Engineering personnel	5,627	22,289

It will be seen that the rapid development of marine steam engineering, and the enormous enlargement of the sphere of utility of machinery of various kinds aboard ships of war have created a new set of conditions, under which the association of engineering with naval power is so intimate and pervasive that it has acquired a predominating influence upon it.

In spite of its undoubted importance, and the fact that it comprises approximately one-third of the total personnel of the Navy, the engineering branch is not represented upon the Board of Admiralty, which is composed entirely of political and naval executive officers. Therefore, the Engineer-in-Chief, who is the responsible head of the department, is placed in a weak and subordinate position, which checks the full and free exercise of his experienced judgment in conformity with what he believes to be necessary for the attainment of the highest possible state of efficiency, throughout the one primarily essential department of our steam navy.

The Education and Training of the Naval Engineer Officer.

Forty years ago the qualifications required of the naval engineer were that he should have served an apprenticeship in an engineering factory, that he should pass a practical examination in the handicraft of his trade, and that he should satisfy the inspector of machinery at the reserve depôt as to his knowledge of the component parts of a marine engine and their uses.

The increase in the magnitude, complexity, and sphere of utility of machinery in the Navy, and the ever-growing numbers of the personnel falling under the departmental control of the naval engineer

officer, rendered it essential for the efficiency of the service that these officers should possess high scientific attainments, and that they should be trained in their youth in the practice of engineering handicraft, and the habits of naval discipline. Arrangements were therefore made for the systematic training of naval engineer students at Government establishments, where the educational requirements, the expenditure incurred by parents and guardians, and the course of training, are such that the social status and mental culture of the engineer officers of to-day fit them to compare favourably in these respects with the officers of the executive and other branches of the service.

Appointments to engineer studentships, at the Royal Naval Engineering College at Keyham, are made by annual open competitive examinations. The students receive a five years' course of combined theoretical and practical training. The theoretical training comprises mathematics, including the calculus and conics, heat, light, sound, electricity, statics, dynamics, mechanics, mechanism, hydraulics, physical laboratory practice, and mechanical drawing.

There are also frequent lectures on steam and the steam engine, combustion, metallurgy, electric lighting, advanced mechanical drawing, and workshop appliances. The practical training includes the manipulation of hand and machine tools, pattern making, smithing, boiler making, and foundry work in iron and brass. The students are employed as opportunity presents itself, upon the work of erecting and repairing machinery of ships afloat, and on board H.M.S. "Sharpshooter" they are given opportunities for gaining some practical experience of engine and boiler-room duties under steam.

During the fifth year, two months are devoted to obtaining some acquaintance with the elementary principles of ship construction and the fittings of ships; five months are spent in the drawing office learning engine drawing and designing, the remainder of the time being occupied in the preparation of drawings from original sketches.

Those students who, in the final examination, gain 60 per cent. of the highest possible number of marks obtain first class certificates, and are sent for one year's further study at the Royal Naval College, Greenwich.

The scientific and mathematical papers, submitted both at Keyham and Greenwich, show that the naval engineer officers are, as a body, at least as highly educated as the officers of the executive branch.

This admirable system of education was instituted by the Admiralty, in order to obtain the same homogeneity amongst the

engineer officers as is the case with the executive officers trained in the "Britannia."

This very object has been, and is still being destroyed, however, by the introduction of so-called "emergency engineers," classified as "temporary service engineers," and "direct entry engineers," the former requiring on entry very elementary educational attainments, and the latter passing directly into the Navy from various technical colleges where the standard of examination is lower than at Keyham. There is also a total absence of training in the habits of naval life and discipline.

Dearth of applicants has apparently rendered these expedients necessary, but the ultimate effect would appear to be the gradual closing of the Keyham College, except for those whose parents are unaware that the same object may be attained by a much less expensive method. The natural and important question is, however, as to the effect of these unsatisfactory expedients on the efficiency of the engineering branch of the Navy.

A statement of the comparative cost of entering the commissioned ranks of the executive, engineering, medical and paymaster's branches of the Royal Navy is contained in the Appendix A of this paper. It will be seen from a perusal of the statement that the costs incurred by parents and guardians for boys entering the executive branch is £494 and the engineering branch £576.

Cost to Country of Training Engineer and Executive Officers.

The cost to the country of training 265 naval cadets on the "Britannia" is £27,443, or £104 per cadet, whilst that of training 194 engineer students at Keyham is £11,624, or only £60 per student.

The last-mentioned figure does not take into consideration the fact that engineer students perform valuable work in connection with the construction and repair of machinery on ships of the Navy.

The total cost to the country of 697 midshipmen and cadets' pay for 1899-1900 was £29,780, or an average of £30 each, whilst 183 engineer students' pay for 1899-1900 was £1,070, or an average of £6 each.

The Duties and Responsibilities of the Naval Engineer.

Forty years ago the duties and responsibilities of the naval engineer officer were confined to the care, maintenance, and manipulation of the

engines, boilers, pumps, pipe connections, the sluice valves between the compartments, and all sea inlet valves.

Some conception of the onerous duties and vast responsibilities which now devolve upon the chief engineer of a modern warship, may be obtained from a perusal of the following extract from the Queen's regulations, stating the items of machinery and parts of the ship which are placed in his care, and for which he is held personally responsible.

(1) The machinery and boilers of the ship and boats (the "Terrible" and "Powerful" have 48 boilers and 25,000 I.H.P. engines, and cruisers are now building with 30,000 I.H.P. engines. Many ships have four steamboats).
(2) All auxiliary machinery for whatever purpose fitted.
(3) All pumps, with the pipes, cocks, and valves belonging to them.
(4) All distilling apparatus, etc.
(5) All gun-mountings and torpedo carriages.
(6) Propeller lifting apparatus.
(7) All steam and hydraulic, pumping, and other engines for loading and working the guns, for supplying ammunition, and for turning turrets, barbettes, platforms, etc.
(8) All ventilating engines and gear.
(9) Capstan engines, shafting and spindle of capstan and windlass, and steam steering engines and steering gear as far as the rudder, with spare gear for the same.
(10) Hydraulic jacks, with the exception of those in the gunner's charge.
(11) Steam winches and gear for hoisting in torpedo and other boats.
(12) All water-tight doors and sluice valves, including horizontal trap and flap doors, as well as vertical hinged doors.
(13) Steam fire engines, and all pipes, cocks, and valves in connection with the fire main.
(14) Instruments and gear for telegraphing signals in connection with the machinery.
(15) Whitehead torpedoes, submerged discharge tubes, and gear for torpedoes.
(16) All air-compressing machinery, reservoirs, separators, and charging columns.
(17) Electric light engines and dynamos.
(18) All flooding gear, including valves, cocks, pipes, and other fittings.
(19) Refrigerating machinery.
(20) All such other parts of the hull, double bottoms, and exposed iron-surfaces as may be in his care, either wholly or jointly with other officers.

Items 5, 7, and 15 should be specially noted.

In addition to the above, the regulations also state :—"That the chief and other engine-room artificers, and chief and other stokers, are to be under the immediate direction of the engineer of the respective

watches, the engineer officer to be responsible for the general decorum, good order, and cleanliness of the engine-room, and he will see that the engineers and the other persons employed under his control perform their duties with promptitude and to the best of their abilities."

Duties of an executive nature connected with evolutions, and inspections of the engine-room ratings and their clothing, also devolve upon him, and make an appreciable demand upon his time.

The chief engineer is also responsible for the whole of the clerical work connected with the department, but as no special clerical assistance is provided, a certain proportion of the valuable time of this officer, and almost the whole time of one of his highly trained assistants is unprofitably expended in that direction. It is obvious that, if he is to successfully perform his varied and important functions, the naval engineer officer must not only possess high professional qualifications, but must also be endowed with considerable administrative capacity, resourcefulness, and decision of character.

The marvellous progress which has been made in war ship design and marine engineering, and the consequent growth of the duties and responsibilities of the naval engineer, will perhaps be better realised from an inspection of the descriptions of typical war ships contained in Appendix B.

The Dearth of Naval Engineer Officers.

The number of engineer officers borne upon Her Majesty's ships of war is dangerously inadequate for the correct and complete fulfilment of the multifarious duties to be performed in accordance with, not only the exacting letter of the Queen's regulations, but with the mere practical necessities of efficiency and safety.

In this connection, the following comparative statements of the complements of officers provided on board certain men-of-war and ships of the Mercantile Marine are significant and interesting.

It is true that the machinery equipment, and the conditions to be fulfilled upon a man-of-war and a mail steamer, are so different that the relative values of the engine-room complements cannot be determined from an inspection of the mere numbers; but, as those differences call for much larger complements on men-of-war, they only emphasise the disproportion revealed.

H.M.S. "Terrible," of which a full description is given in Appendix B, is fitted with two sets of triple expansion engines capable of

developing a total of 25,000 I.H.P. She carries 1 fleet engineer, 1 engineer, 5 assistant engineers, and 1 artificer engineer—a total of 7 commissioned and 1 warrant engineer officers. In addition there are 3 chief engine-room artificers, and 15 engine-room artificers, but the artificers, although mechanics, have no direct responsibilities.

Neither the chief engineer nor his senior assistant can take regular watches, as their general supervision must be constantly exercised over the whole of the machinery throughout the ship, and it must be remembered that a large portion of the time of the chief engineer, and almost the whole of the time of one assistant engineer is absorbed in the clerical duties appertaining to the department. Therefore there are only 6 engineer officers available for regular watch-keeping, although the Admiralty instructions state that the officers must personally superintend, and are held responsible for the whole of the work of the department. As an example of the strict interpretation of this regulation, the Court Martial held upon the chief and senior officers of H.M.S. "Blake" may be cited. These officers were severely reprimanded and dismissed their ship for not having personally superintended the fitting of water-gauge glasses by an artificer, at a time when important work connected with getting the ship under way demanded their attention elsewhere.

The Cunard Co.'s R.M.S. "Lucania" is fitted with twin screws, and two sets of triple expansion engines capable of developing a total of 28,000 I.H.P. Each set of engines comprises 5 cylinders, 2 H.P. 37 inches, one I.P. 79 inches, two L.P. 98 inches, the stroke being 69 inches. The steam is supplied by 12 main and 2 auxiliary boilers, having a total number of 102 furnaces. The auxiliary machinery comprises air, circulating, feed, bilge and fire pumps, evaporating and distilling plant, fans, electric light and refrigerating engines, and the usual deck machinery. She carries 22 engineers, of whom 10 hold first class and 3 second class Board of Trade certificates, 2 electricians, 1 boilermaker, 24 greasers, 78 firemen, 60 trimmers, 2 storekeepers, and 2 donkeymen. There are 7 engineers in each watch.

The White Star Co.'s R.M.S. "Oceanic" is fitted with 2 sets of triple expansion engines, capable of developing a total of 28,260 I.H.P. She carries 23 engineers, of whom about 15 hold first class Board of Trade certificates, and 34 greasers and water tenders. There are 7 engineers in each watch.

H.M.S. "Vengeance," first class battleship, fully described in Appendix B, is fitted with 2 sets of triple expansion engines, capable of

developing a total of 13,500 I.H.P. Vessels of this class carry 6 engineer officers. There are in addition 3 chief engine-room artificers and 9 engine-room artificers.

One representative vessel of this class, at present in commission in the Mediterranean, carries 1 fleet engineer, 1 engineer, and 4 assistant engineers (of whom no less than 3 are probationary).

The Cunard Co.'s R.M.S. "Umbria" is fitted with 1 set of engines of 14,500 I.H.P. She carries 10 engineers, of whom 5 possess first class and 2 second class Board of Trade certificates, 2 electricians, 1 boilermaker, 9 greasers, 54 firemen, 40 trimmers, 1 storekeeper, 1 donkeyman. There are 3 engineers in each watch.

First class cruisers, fitted with 2 sets of engines of as much as 16,500 total I.H.P., 30 Belleville boilers, and about 72 auxiliaries, carry from 6 to 7 engineer officers. From 4 to 5 of these officers are "assistant" or "probationary assistant" engineers, most of whom are mere youths with from two or three months' to two or three years' sea-going experience.

H.M.S. "Crescent," a first class twin-screw cruiser, of 10,000 I.H.P., N.D., and 12,000 I.H.P. F.D., which is at present the flagship on the North-American Station, carries 1 staff engineer, 1 engineer, and 3 assistant engineers.

In a well-known line of mail steamers running to South Africa, the twin-screw boats, fitted with 2 sets of engines, having a total of 10,000 I.H.P., carry 13 engineers, of whom 9 possess Board of Trade certificates. There are 4 engineers in each watch.

Innumerable comparative instances might be cited, but the above will suffice to reveal the great disparity between the complements of engineer officers carried in the Navy and the Mercantile Marine respectively.

On ships of the Royal Navy, the ratio of engineers to men ranges from 1 to 21 in battle ships, to 1 to 37 in ships of the "Terrible" class, and rises as high as 1 to 48 in some destroyers.

Taking the "Lucania" and "Oceanic" as typical examples of Mercantile Marine practice, the ratio of engineers to men is about 1 to 8.

It should here be stated that the naval complements cited above are those provided in time of peace on board ships in commission on the most important stations.

Some slight idea of the character of the complements of engineer officers, which will be available when the whole of our Navy is

mobilized on a war footing, may be obtained from a perusal of the following extract from a pamphlet entitled "The Royal Naval Engineer as Student and Officer":—

"It is a noteworthy fact, showing how desperately shorthanded the Navy is for engineer officers, that during the manœuvres just completed, 1899, more than one-half of the R.N.E.'s who have directed and assisted in the work of the engine-room staff on all the cruisers and battleships engaged have only had two years', or even less, service in the Navy (some 35 or 40 of them passed out from the R.N.E. College last June). Each of these young officers is now expected to do the work which, ten years ago, was allotted to two R.N.E.'s, and which in time of 'real' war it would be utterly impossible for them to perform. It is doubtful whether if re-inforced to the extent of one-third their present numbers they would even then be on a sufficiently strong war-footing."

A large proportion of the junior engineer officers attached to ships in commission have had less than two years' service, and many of them have had only a few months' experience afloat. These inexperienced junior engineers are, of course, quite unfitted for independent action and responsible duties. They have to be trained by the seniors, and are consequently for at least two years a source of extra anxiety and work rather than effective assistance.

When the young engineer leaves Keyham and joins his first ship, he is absolutely lost, because he has not yet learnt the practical significance and bearing of the theoretical knowledge which he has acquired, and he is, therefore, quite devoid of that judgment, resource and confidence which can only be created by long and intimate acquaintance with the machinery. These young engineers should undoubtedly be borne as supernumeraries for training, and should not form part of the engine-room complement amongst whom the responsible work has to be distributed.

In estimating the relative values of Naval and Mercantile Marine engine-room complements, it must be remembered that in mail steamers and other high-class high-powered vessels in the Merchant Service, the engineers are most carefully selected from the large number which is available, and that a considerable amount of previous experience in engine-room duties afloat is an essential qualification for the recipient of an appointment as a responsible watch-keeping officer.

It is also customary for the members of the engine-room staff to remain for long periods in one ship. They are thus enabled to become thoroughly familiar with the minutest details of the machinery, and the lengthy association of the men creates a feeling of mutual confidence and

interest, which cannot but tend to enhance the efficiency of the whole body.

It is a fact well known amongst the responsible heads of our engineering industries, that of the total number of boys who serve an apprenticeship in engineering establishments, only a very small percentage are endowed with those qualities which enable them to emerge from the crowded ranks of mediocrity.

In the Navy, every engineer student who succeeds in passing out of the Royal Naval Engineering College at Keyham automatically rises through the various ranks until he attains a position involving great responsibilities, and demanding exceptional qualities for their proper fulfilment.

The number of students entered is small, and the demand for officers is great. Therefore, on the one hand, the law of averages precludes the possibility of obtaining an average sample truly representative of the material obtainable in such a country as our own ; whilst, on the other hand, the necessity for replenishing the ranks to compensate for the depletion due to promotion, retirement, and the ever-increasing number of our ships, further prevents the continuous maintenance of a high standard of excellence.

The conditions and exigencies of the Naval Service give rise to very frequent changes in the composition of the engine-room staff of a ship, and it is a very usual occurrence for a ship to enter upon a commission, and participate in complicated fleet manœuvres, or start out upon a long voyage, with an engine-room complement comprising a preponderating proportion of officers and men who are total strangers to her machinery. This is no doubt unavoidable, but it surely indicates that naval engineer officers, who are called upon to undertake responsibilities under such conditions, should be engineers of exceptional capacity and ripe experience.

Mr. Frank T. Bullen, who is himself an ex-officer in the Merchant Service, in his highly interesting little book entitled *The Way they Have in the Navy*, describing his experiences on board the first class twin-screw battleship H.M.S. "Mars" (10,000 I.H.P., N.D., 12,000 I.H.P., F.D.) during the manœuvres of 1899, makes the following statement regarding the engine-room complements in the Navy :—

"It is no doubt a bold assertion to make, but from a personal comparison of the two I feel perfectly justified in saying that in both men and morale a first class battleship is far worse equipped in the engineering department than any ordinary liner

"The following figures will not appeal, of course, to landsmen very much, but to sea engineers unacquainted with the Navy they will be terrifying. For the battleship whose complications I have been describing above—1 fleet engineer, 1 engineer, and 4 assistants, the oldest of whom is 23 years of age, and the youngest just out of Keyham College.

"Is it any wonder, then, that the chief engineer is practically always on duty? He trusts his young confreres fully, as he must do if he would remain sane; but at the same time he must be ready to rush to their assistance at any moment.

"Beneath the assistant engineers come 3 chief engine-room artificers (E.R.A.), and beneath them again the engine-room artificers, of whom there are 9. These hold the rank of chief petty officers and petty officers respectively, and, as in the deck departments, they are the backbone of the engine-room. But they are not responsible men. If they fail at any time it is the engineer's blame, and his punishment for a failure he was absolutely powerless to foresee, or attempt to prevent, is infinitely greater than theirs.

"In the stokeholds there are 6 chief stokers, 11 first class leading stokers, 5 second class leading stokers, and 108 stokers, all of whom are under the immediate supervision of the youth who happens to be on watch at the time as assistant engineer. And, as if that were not enough work for these young men, one of them must expend most of his time in purely clerical duties—for, unlike any other department of the ship, there is no clerk allowed for the engine-room staff."

And, later on, in Mr. Bullen's concluding remarks upon the engineering department, one finds the following significant passage:

"I think I have said enough, even in these few lines, to show why the berth of naval engineer becomes harder and harder to fill, and it becomes necessary to trust the engines of our most gigantic men-of-war to clever but inexperienced lads, under the control of one older man, whose responsibilities are so tremendous that he dare not think of them."

Undermanning in the Engineering Department.

Unfortunately, the weakness of our naval engine-room complements is not limited to a lack of numbers and experience in the ranks of the engineer officers.

Owing to the normal state of prosperity of skilled mechanics in this country, it has not been possible to obtain a sufficient number of thoroughly skilled artificers, and in order to procure the numbers provided for in the estimates, it has unfortunately been necessary to admit a large proportion of men of inferior capacity.

The engine-room artificer is a most valuable and indispensable member of the engine-room staff, and it is highly desirable that means should be devised for inducing the right class of men to enter the service.

The stokers are drawn from various classes of unskilled labour, and

the vast majority of them have had absolutely no experience of boilers or machinery before entering the Navy.

There is no system for effectively training stoker recruits in stokers' duties before drafting them to ships in commission, and it is customary for about one-third of the total number of stokers in a ship to be absolutely green hands.

The minute subdivision and wide distribution of the coal bunkers on board men-of-war necessitates the employment, upon the work of trimming and passing coal, of a number of men which is out of all proportion to the requirements in the Merchant Service.

This point is well brought out in the following extract from a series of articles entitled "The Engineer Officers of the Royal Navy," which appeared in *The Engineer* last year :—

"Quite recently one of our large and modern cruisers ran a trial of sixty hours' duration at about seven-eighths of her maximum indicated horse-power; this entailed the additional services of 60 seamen to enable the coal to be trimmed with sufficient rapidity to supply the boilers. She, like many others, has about 50 coal bunkers. This is a condition that would obtain every day in war time, when these seamen would be required for other duties and could not be spared for such work, and it clearly shows the weakness of the stoker complements."

It is an astonishing fact that in 1892, at a time when the Navy was in a state of rapid development, and the engineering personnel was already known to be inadequate, the Board of Admiralty decided to reduce the engine-room complements by about 12 per cent., the change involving the substitution of chief stokers for a certain proportion of artificers, thus effecting a reduction in mechanical skill as well as in the numbers of the engine-room staff.

The unpopularity of the engineering branch of the Royal Navy, and the consequent difficulty experienced in obtaining the required numbers of officers and men of the various ratings, have led to expedients being adopted at various times to fill the gaps. These expedients have invariably involved a lowering of the standard of both officers and men, which is highly detrimental to the efficiency of the service.

At the present time it is impossible to provide full engine-room complements for the whole of our ships in the event of mobilisation, and even if it were possible to provide the mere numbers, it must be remembered that under the existing system the engine-room complements of the majority of the ships would contain so large a proportion of inexperienced junior officers, artificers of inferior skill, and stokers without any knowledge of boiler-room duties whatever, that it would be

nothing short of miraculous if the conditions attending actual warfare did not lead to disaster.

There is a popular belief, which has certainly not been discouraged by official utterances, that in time of war the military spirit and patriotism of the engineers and mechanics employed in the Mercantile Marine, and in our shipbuilding and engineering industries, will lead them to offer their services to the Navy in such numbers that all deficiencies of personnel can be made good. This is a most dangerous belief, and it will be an evil day for the nation when it depends for its success in a naval war upon its realisation. The very special character of the boilers and machinery in use upon modern warships renders it quite impossible for even a sea-going engineer from the Merchant Service to become sufficiently familiar with them to fit him for responsible duties in less than two or three months. In the case of a landsman, it would take that time for him to acquire the sea-habit alone, and considerably longer before he would become a useful member of the engine-room staff.

Moreover, the conditions under which the duties of the engineering staff would have to be executed in time of war are so peculiarly trying that perfect discipline and mutual confidence are essential to their satisfactory performance, and these qualities can only be created by long training and association.

Weighty testimony to the supreme necessity for maintaining a high standard of excellence in the engineering branch of the Navy is afforded by the following extract from an article entitled "Readings from Experience in Naval Engineering" (which appeared in the *Engineering Magazine* for March, 1899), by Rear-Admiral George W. Melville, who by his great professional attainments and far-sighted policy, in his capacity of Engineer-in-Chief, has contributed so much to the creation of the present high state of efficiency of the engineering department of the United States Navy :—

"The utter failure of Cervera's fast armoured cruisers, which had trial speeds of 20 knots, to escape from the United States vessels at Santiago, none of which were making 17, shows the disastrous results of discouragement of the mechanic. As we now know, the condition of the two fastest ships at Santiago, the 'New York' and 'Brooklyn,' was such that only half power could be used immediately, and it seems almost certain that, had Cervera's ships been able to make their maximum speeds, they would have escaped. The mechanical instinct, too, is just as important for the care and manipulation of the modern guns and turrets as for the care and manipulation of the motive power, I believe that in this respect also the mechanical aptitude of the American people was an important factor in the victory."

The Present Position of Engineer Officers.

The engineer officers have published a statement of the reforms which their experience leads them to believe to be necessary, in the interests of the efficiency of the engineering department of the Navy. That statement is so clear and concise that it has been deemed advisable to append it to this paper in its entirety. (See Appendix C, page 215.)

The engineering department of the Royal Navy is included in the civil branch of the service, the whole of which is subordinate to the executive or military branch, and the officers of which receive no military rank or title, and are not empowered to award punishments to their departmental subordinates for any offence whatever. So-called "relative" rank has been assigned to naval engineers, apparently with a view of simply defining their order of precedence as commissioned officers in H.M. service, but it carries with it absolutely no powers affecting the performance of their duties. Throughout their active career they remain plain "Mr.," and are retired as civilians, with no mark or outward sign to denote that their lives have been spent as officers in a military service.

The civilian rank of the engineer officer and his consequent inferiority to every officer of military rank places him in many anomalous and humiliating positions, and completely undermines his authority over the men in his own department whom he is expected to control without being invested with any powers of punishment or reward. If an offence is committed, the engineer officer and the defaulter appear before the commander at the hour appointed for dealing with offences. In many cases the offence is technical, and the commander, being possibly unable to appreciate its gravity, may consider it trifling, and merely sentence the man to be punished by standing at attention and looking seaward for so many hours. If the commander considers the offence grave, then the engineer and the man resume their duties and re-appear before the captain the next day. The offender is never sent to work out his punishment in the engine-room, but always on deck, and always unremuneratively, as regards the engineering department, so that a calculating criminal engaged in a boiler-room or bunker in the tropics may commit an offence with considerable personal advantage. To fully appreciate the evil effects of this deplorable system, it must be remembered that stokers, unlike seaman, enter the service at an adult age, and are, therefore, not trained from boyhood under strict naval discipline. They are as untrained as many of their brothers in the Mercantile Marine, and are correspondingly difficult to manage. How,

then, is it possible that, under such conditions, the civilian engineer officer can get the best work out of his men? If there is one department in a modern warship in which officers require to be vested with plenary authority surely it is the engine department, where the work is of the hardest and most trying nature, and also of such technical importance that trifling carelessness might easily result in serious consequences. To those of our members who are superintendent engineers, the wonder will be that such a system can produce anything but failure, as it is in direct opposition to what experience has shown to be necessary for success, both in industrial establishments and upon ships of the Mercantile Marine. Failure is ahead, however, and all that is required to develop it is a naval war.

Those officers in the highest ranks of the service, who are responsible for the policy of withholding executive rank from engineer officers, are surely adopting a very dangerous course. Such a change would in no way lessen the power of the executive branch, whose assumed interests they are now too jealously guarding, whilst it would vastly increase the efficiency of a branch which deserves all the assistance and encouragement which can be given to it. It can only be presumed that they do not realise the evil effects of their policy, though it is very difficult to believe that they have failed to hear the warning voices of those influential and competent authorities who have long predicted the disastrous consequences which must inevitably ensue when the Navy is called upon to pass through the crucial test of battle.

The systematic repression of the engineer as an individual has no effect, per se, except that of making the service unpopular for engineers, but its bad effect upon the general efficiency of the entire engineering branch is undoubted, and constitutes a danger which should be recognised and dealt with.

Our engineer Members of Parliament are, of course, fully aware of the danger, and that they do not succeed in causing its removal clearly shows how powerful are the reckless opponents of reform.

It should be clearly understood that the object of this paper is not to advocate that engineers should hold military rank merely to satisfy personal vanity, as they no doubt rightly consider that their profession of engineer does not require further adornment. The question is, therefore, not personal but national, and resolves itself into whether the efficiency of the engineering branch can be increased. It is immaterial to the nation whether or not the engineer as an individual objects to be classed as a civilian having no executive control over his men, but in a

naval action it may make the utmost difference to the nation if the artificers and stokers give a higher interpretation to the rank of Lieutenant Smith, R.N.E.C., who has power to punish offenders when on duty, than they do to civilian Mr. Smith, who has no such power. There are no men who have a greater respect for the power which rank confers than sailors and soldiers, and it is absolutely unquestionable that the efficiency of the entire engineering branch would be very largely increased if those officers were formed into a military corps, and vested with power to deal with all minor offences, such as are now dealt with by commanders. It would seem unnecessary that power to punish should be extended beyond those offences committed when on actual duty in the engine department, as all offences when off duty could be dealt with by the commander or captain, as at present.

Still another feature of the utmost value accruing to the change would be the increased popularity of engineering in the Navy. The effect of the policy of repression is discontent, and when parents appreciate the present position they will very naturally dissuade their sons from becoming naval engineers. This result is already being felt, and although we are told in Parliament that there is no lack of engineers, yet the fact remains that notwithstanding the great efforts which are being made, their numbers are very disappointing.

There are other aspects of this question of rank which, although apparently more sentimental and personal than practical and national, have nevertheless a very direct bearing upon the efficiency of any officer in a fighting service.

It is well to remember that it is only sentiment in one form or another that impels men to risk their lives, and lay them down if need be, for their country.

In this connection may be quoted the following extract from a speech by the Marquis of Landsdowne, relating to the concession of military rank and title to Army medical officers :—" I sometimes hear it said, ' What does rank matter ? Is not the title of doctor or surgeon by itself to be regarded as a title which anyone would be proud to bear without further adjuncts ? ' I think the answer to that is, that in the Army, rank is the outward and visible sign of consideration and authority, and that, although a ' man may be a man for all that,' it is necessary, if he adopts the military profession, that he should have a military stamp to distinguish him, and to secure him his proper place amongst his comrades."

It is also interesting and suggestive to recall the following

passage from a speech made by Mr. Goschen in the debate on the Navy estimates, 1877-8:—"It (rank) was a matter of extreme importance to the well-being of the ships, and it ought to be dealt with in a broad and comprehensive manner. If the engineers were to have equal pay with the other branches of the service, but inferior rank, that branch would not attract equally able and good men. We had to think of the safety of our ships, and to consider whether the authority of engineer was so great and so well defined as it ought to be."

The Pay of Engineer Officers.

In addition to his inferiority in rank, the engineer officer is at a distinct disadvantage in the matter of pay.

A sub-lieutenant can become a lieutenant at 23 years of age, after 3 years' service, and he then has his pay increased from 5s. to 10s. per day, which latter rate is only attained by the engineer after 9 years' service, when he is usually about 30 years of age. The engineer has to serve 11 years before he obtains 11s. per day, whilst the naval surgeon receives 11s. 6d. per day when he first enters the service at 21 years of age. The engineer continues to receive 11s. per day until he is 34 years of age, whilst in the meantime the rates of pay obtained by the naval surgeon and the paymaster rise to 21s. and 15s. per day respectively. At 35 years of age the executive officer has generally attained the rank of commander, with 20s. per day. The surgeon is then in receipt of 21s., the paymaster of 15s., and the engineer of 14s. per day, and it is only at 47 years of age that he becomes a "fleet engineer" and receives 20s. per day.

The maximum rates of pay for fleet surgeons, fleet paymasters, and fleet engineers, are 33s., 33s., and 20s. per day respectively.

Engineer officers, when in charge of the machinery on one of Her Majesty's ships, receive, in addition to the above-mentioned rates of pay, an allowance called "charge pay," which varies from 1s. to 9s. per day, according to the size of the ship and the character of her machinery. This allowance is not taken into account for leave, invaliding, or superannuation. The rate of "charge pay" relatively to the responsibilities incurred by the engineer has been decreased during the past 12 years. Twelve years ago the chief engineer of H.M.S. "Polyphemus" (2,640 tons, 5,500 horse-power) received 9s. a day charge pay, and had 5 or 6 assistant engineers to help him. Now, such monsters as the "Powerful" (14,000 tons, 25,000 horse-power) only entitle their fleet engineers to 9s.

is impossible not to admire the true British pluck of these officers as, notwithstanding all their service disabilities and the anxiety consequent on the rapid development of steam engineering in the Navy, which often involves radical changes and inevitable experiments, they do their work with dogged perseverance, and never give in until the intense nervous strain affects their health, which unfortunately is too often the case even in these times of naval peace.

The fact that the Admiralty does not adopt the obviously just and fair course of promoting these junior officers to "chief engineer" rank would seem to indicate that such a policy would seriously deplete the junior ranks, and by destroying the proper proportions of the various ranks would upset the traditional system of pay and promotion, and would draw attention to the inadequacy of the annual supply of engineers.

The monstrous injustice of this system would find a parallel in the Merchant service if the chief engineer of one of our mail steamers were suspended, and the second engineer appointed to take up his duties and responsibilities whilst still retaining the position and pay of second engineer.

The men of the engine-room staff, more especially those of the stoker ratings, are trained to perform combative duties in connection with the armament, landing parties, etc., and they then come under the direct control of the executive officers, whose orders at all times take precedence over those of the engineer officers.

The commands for the performance of these extra departmental duties are generally made in an arbitrary and unexpected manner, and when the engine-room staff is busily engaged upon important overhaul and repair work, whilst the ship is in port, they frequently completely disorganise the chief engineer's plan of work. The fact that the engine-room complement at his disposal is diminished, however, in no way relieves him of his personal responsibility for the execution of all work necessary to maintain the machinery in a state of efficiency.

Courts Martial.

Courts martial for the trial of engineer officers for even technical offences are constituted entirely of executive officers, who are not qualified to understand the intricacies of engineering technicalities. Without reflecting in the slightest degree upon the honour and integrity of the members of such courts martial, it may truly be said that they

are necessarily quite incompetent to appreciate the significance of much of the evidence which it is their duty to sift and adjudicate upon.

Prohibition of Communication with the Engineer-in-Chief.

The engineer officer is entirely cut off from direct communication with either the Board of Admiralty or the engineer-in-chief of his own department. His communications must all be addressed to the captain, who not only has power to comment upon, or even suppress the document, but is by regulation obliged to have it transcribed and forwarded in his own name, so that the individuality of the engineer officer is absolutely sunk.

The conditions of the naval service no doubt demand that all official communications with the Admiralty should pass through the hands of the captain, and that he should have the right to comment upon them; but it is very doubtful whether it is in the interests of the nation that any communication from a responsible officer should be liable to suppression. It is impossible to conceive any good reason for the transcription of a letter composed by an officer whose educational qualifications certainly fit him to express his ideas intelligently, and to address the authorities in suitable language. This is only one illustration of the systematic manner in which the individuality of the engineer officer is obliterated, excepting on such occasions when blame has to be apportioned.

It will be seen that the vast responsibilities of the naval engineer are not accompanied by a corresponding power of control, or by adequate assistance for their proper fulfilment, nor does the position carry with it the rank or emolument due to its importance, and to the necessarily high qualifications and onerous duties of its occupant.

The Influence of the Engineer upon a Naval Action.

The influence of the naval engineer upon the result of an action can scarcely be over-estimated. The first essential of a modern war ship is that she shall be able to steam, as and when required, in conformity with the wishes of her commander, based upon the expectations as to her powers, which have been created by the official data supplied to him.

Any failure of duty on the part of the engineer, or lack of efficiency of the machinery, might render it impossible to place or maintain the ship in a position for effective action, or to make use of her armament. Therefore, the whole of the potential powers of the entire fighting

machine are dependent, for their active development, upon the mobility of the ship, and the workability of her armaments, for both of which the engineer is primarily responsible.

In action the engine-room staff, closed down below the protective deck, amid a stifling atmosphere, are called upon to perfôrm duties upon which the whole utility and safety of the ship may depend. The intense nervous strain, created by the realisation of the grave though unknown dangers to which they are being subjected, is unaccompanied by the inspiriting excitement of battle, which so greatly enhances the human powers of endurance. Under these conditions, strict discipline, cool judgment, and an intimate knowledge of the vast maze of mechanism, are essential to the successful performance of the necessary duties.

One cannot forget the lives which, even in times of peace, have been sacrificed in the engine-rooms of Her Majesty's Navy—deaths displaying a noble devotion to duty, and resulting from explosions and accidents, appalling and horrible in their associations and effects, upon which it is painful to dwell. Such accidents must inevitably occur with greater frequency in the stress of battle, when the entire mechanism is strained to the utmost, and in view of the terrifying effects of escaping high pressure steam there will, at times, be a great tendency to demoralisation.

It is at these times that the immense value of the engineer officer will be made apparent. He is the man who alone can inspire or restore confidence, and who, by his skill, experience, and cool judgment can minimise the consequences of an accident and initiate the method of repair. It is he who, in moments of dire emergency and panic, when all others fail, will have to remain at his post, and face death if need be, in the fulfilment of his duty; unstimulated either by the glory and glamour of battle, or by the hope of that personal distinction and recognition which fall to the lot of the ordinary combatant. Is it just or wise, in time of peace, to rob this responsible officer of that rank and authority which are so vital to the exercise of complete disciplinary control; and then, in time of war, to place him in a position where, under the most difficult circumstances, he is called upon to exercise absolute control over men who have been taught to regard the executive officer as the sole representative of plenary authority?

The danger of such a policy is magnified by the fact that the members of the engine-room complement are mainly enlisted at an adult age, and having been subjected to naval discipline for only a short

period, are lacking in that instinctive habit of unquestioning obedience and self-repression which is so invaluable when duties have to be performed in the face of personal danger. Moreover, during an action, the engine-room staff are entirely removed from the jurisdiction of the executive officer, and the engineer officer has, therefore, to rely entirely upon his own personal influence to secure obedience and induce discipline.

The serious issues involved in the execution of their duties, the great potential dangers residing in the boilers and moving machinery, and the knowledge that any revealed error of omission or commission will be made the subject of a court martial, necessarily impose a very severe strain upon the responsible officers. Under such conditions of life, contentment, enthusiasm, and freedom from avoidable causes of irritation are essential to the maintenance of the human machine in a high state of efficiency.

It will be seen, however, that the naval engineer is called upon to undertake grave personal responsibilities without adequate powers of control, and to perform important and multifarious duties without adequate assistance. He is ever liable for blame, and seldom eligible for commendation. Under such dispiriting conditions of life, the conscientious performance of his mere duties becomes an act of almost heroic virtue. When young, he regrets having entered the service. When old, he looks anxiously forward to the time when he will be permitted to lay down his heavy burden and retire from the service, hoping that he may be fortunate enough to escape the numerous pitfalls which beset his path, any one of which may land him into a court martial, and envelop the termination of his career in an atmosphere of disgrace and humiliation.

This is the man whom the nation may require at any moment to perform, under circumstances requiring the greatest courage and devotion, duties which are vital, not only to the safety and combative efficiency of the ship and her crew, but to the highest interests of the nation which it is their purpose to defend, and who may be called upon to make the ultimate and greatest sacrifice which a man can render to his Queen and country.

Grave Danger of Present Position and Necessity for Prompt Action.

So long as the present serious state of affairs in the engineering branch of the Royal Navy is allowed to continue there is undoubtedly a

grave danger of disaster overtaking us in a naval war. The paper values of ships will not count in warfare, and should a ship be unable to steam in accordance with the requirements, she would not only run the risk of being put out of action and falling a prey to the enemy herself, but by being unable to fulfil her functions at the critical moment, she might endanger the other vessels in the fleet and imperil the vital issue of a closely contested engagement.

The conditions of modern naval warfare render it impossible to make good defects in organisation, equipment, or personnel after war has been declared, because a naval war must necessarily be of short duration, and the high degree of skill and special knowledge required to fit the men in every department for the efficient performance of their duties cannot possibly be acquired in the short period of time available.

It will be of far greater value if our efforts are primarily devoted to increasing the efficiency of our existing ships rather than to increasing their mere numbers and paper values, unaccompanied by the removal of those points of weakness, which at present make it impossible to render our theoretical naval power really existent and effective.

There is a tendency, even in some high and responsible quarters, to display a very spurious kind of calm which confuses preparation with panic, but surely no merit can be claimed for the "too late" method, which ignores weak spots and defects until they are revealed at a moment of national danger; when, owing to the neglect of every precaution dictated by reason and duty, disaster mercilessly brings them into the full light of publicity, and necessitates the hurried and uneconomical expenditure of energy and wealth, with the result that, even at the best, the nation is robbed of many initial advantages, which would be gained had the remedies been opportunely applied.

Public ignorance, regarding such questions as that which is the subject of this paper, renders it dangerously easy for the responsible authorities, by means of specious arguments and incomplete statements, to create a feeling of public confidence which is quite unwarranted by the true facts of the case. The experiences of the past do not encourage thinking men to repose blind confidence in those who are at any given time, according to the vicissitudes of party politics, entrusted with the safe-guarding of our empire. Our whole national history teaches us that reforms, no matter how obviously essential, are rarely brought about otherwise than by the force of organised and intelligently-directed public opinion.

Unfortunately, the questions at issue are, to a great extent, so special and technical that, by the means hitherto adopted, it has been impossible to educate public opinion up to that state of enlightenment which alone can endow it with intelligent activity and determination, and disaster would seem to be necessary in order to convince the responsible authorities that reforms are absolutely necessary in the engineering branch of the Navy.

The executive branch, which alone is represented on the Board of Admiralty, is, to quote the words of one of its own members, "a close corporation," which is very jealously guarded, in strict conformity with traditions and ultra-Conservative principles that are in many respects irrelevant to, and out of harmony with, the requirements of a modern steam navy. The interests of the nation demand that the Navy shall be constituted and administered in accordance with those principles which are best calculated to conduce to the attainment of maximum efficiency, and traditional prejudices should not be permitted to interfere with the institution of reforms which are obviously necessary for the welfare of the empire.

The existing difficulties and defects were recognised more than 20 years ago, in the early stages of their growth, by such prescient and liberal minded authorities as Admiral Sir Cooper Key, Admiral Followes, and Sir Edward Reed; and the necessity for drastic reforms in the engineering branch of the Royal Navy has been constantly urged during the whole of the subsequent period, but unhappily without any effect whatever.

In more than one instance, those who have in their public utterances recognised the need for reform have passed into the highest administrative position at the Admiralty, but, strange to say, they have hitherto failed to give any practical effect to the beliefs which they had formerly expressed.

It is an interesting and significant fact that, as far back as the year 1876, an Admiralty Committee, under the chairmanship of Sir A. Cooper Key, which was appointed to inquire into the condition of the engineering branch, reported unanimously as follows:—"The chief engineer has a large body of men under his immediate orders, many of whom are quartered at guns, and have to take an active part in action. His duties are in many respects executive. We are, therefore, of opinion that engineer officers should in future be classed with the military or executive branch of the profession, among those who would not on any occasion succeed to command." That important recommendation has

not, up to this day, been adopted, although during the 23 intervening years of inaction the necessity for the change has become daily accentuated by the rapid development of the new conditions.

It is surprising, indeed it is alarming, but nevertheless true, that in spite of the undeniable importance of the questions at issue, and in defiance of unmistakable evidence of the urgent need for their satisfactory solution, the Admiralty have, up to the present time, given no sign of their appreciation of the position or of any sincere intention to rectify it. Such apathy is inexplicable, in the face of an array of facts which should constitute the strongest incentive to action on the part of a public department which has no legitimate interests to serve but those of the nation, and whose first duty it is to place the Navy in the highest possible state of efficiency and preparedness for the performance of its ultimate momentous functions.

With a determined persistency, every effort is being made to retain a system which has long outlived the conditions under which it was created, and which is quite unsuited to the present requirements of the service. It is, therefore, not surprising to any unprejudiced mind that the present state of things has caused a feeling of intense dissatisfaction to permeate the ranks of the naval engineers, which strikes at the very root of efficiency, and, were the true state of affairs known and realised by the general public, there would be a natural anxiety and a disturbance of confidence which, unfortunately, would be only too well justified.

This question cannot be ignored. It is a grave national danger, and an immediate solution is imperative, in view of our vast and increasing Imperial responsibilities, and of the large number of high-powered complicated ships of war now in course of construction, for which it will be impossible to find engine-room complements of adequate numbers, skill, and experience.

In view of their special ability to understand the nature and full significance of the more or less technical questions which are at issue, it is a duty which the engineering professions owe to the country to lend their powerful advocacy to the cause of reform. That duty devolves with particular directness upon marine engineers, and members of this and kindred institutions. The gravity of the question demands their attention. Let them speak with no uncertain voice, and give to the nation the benefit of their life's experience, and their true and fearless estimation of this national danger.

In order to fulfil any useful purpose, their support must be active, and must take the form of arousing professional and lay interest in the

subject, by collecting and disseminating full information as to the facts of the case, and by bringing the subject under discussion at the meetings of the various engineering institutions. Such action can be effectively undertaken only by an organised body, and the writer would venture to suggest that a committee, representative of the engineering professions of the country, should be formed to deal with the matter.

There could be no better conclusion to this paper than the following impressive and eloquent passage, extracted from one of those famous letters which Sir E. J. Reed wrote to *The Times* in 1877:—"If this Navy of which I am writing belonged to the few politicians and admirals who regulate it we might smile at the absurdity of such arrangements, and there leave the matter. But . . . . the Navy of Britain belongs to the people of Britain, and the depression, I would even say the degradation, of a class of officers upon whom its efficiency and glory must so largely depend in future, is a matter of the most serious public concern. . . . . It is shameful to leave an evil of this kind to wait for redress until the engineers themselves require and demand it. Their interest in the matter, however great, is only secondary; it is for the country's interest that the position of naval engineers should be raised to a level corresponding to the greatness of their present trust, and to the weight of their enlarged responsibilities."

ADDENDUM.

Since the above paper was written, the statement of the First Lord of the Admiralty, explanatory of the Navy estimates for 1900-1901, has been published, and it contains the following passage referring to engineer officers:—

"The promotion, status, and pay of engineer officers have been recently considered by a committee of the Board, with the result that the following changes have been approved:—The list of chief inspectors of machinery has been increased from 5 to 8, and that of inspectors of machinery from 8 to 13; the Engineer-in-Chief has been given the relative rank of rear-admiral; the rank of staff-engineer has been abolished; chief engineers will rank with lieutenants of eight years' seniority, instead of, as now, with but after lieutenants, and engineers on promotion will rank with lieutenants instead of with but after. In other respects the relative rank of engineer officers remains unchanged. Engineers will be given a new scale of pay, viz:—

On promotion	10s. a day.
After 4 years	11s. a day.
After 8 years	12s. a day.

—and the allowance of 1s. a day at present paid to senior engineers for all ships will be replaced by a scale varying according to responsibility, from 1s. to 2s. 6d. a day.'

It will be seen that the changes proposed are of a trivial character, and leave untouched all the questions of vital importance.

It is difficult to conceive the spirit which prompts responsible ministers and public officials to deal with national interests in a manner which would appear to indicate that their chief object is to stifle criticism by granting minor concesssions, and so create an impression in the public mind that the entire question has been thoroughly considered and effectively dealt with.

APPENDIX A.

Comparative Costs of entering the various Commissioned Ranks of the Royal Navy.

The following interesting extracts from a letter by a retired naval officer were given in the *Naval and Military Record* of the 29th September, 1898, making a comparison between the expense of educating two of his sons—one for the engineering branch, who started his Keyham course at 16, the other for the medical branch of the Navy at 17. He says, "My estimate, based on actual figures, and there was no stint in either case," is as follows :—

Engineering Branch.—(Boy starts at 16.)

	£	s.	d.
Entrance examination	1	0	0
Five years' course at £40	200	0	0
Uniform at start	50	0	0
Plain and underclothing	50	0	0
Recreation fund (partly compulsory) five years	25	0	0
Books, stationery, models, instruments	50	0	0
Annual expenses, washing, etc., plain clothes, uniform, and details, £40 per annum	200	0	0
	£576	0	0

Medical Branch.—(The boy started at 17.)

	£	s.	d.
School for one year	100	0	0
Matriculation examination	1	0	0
Hospital fee (London Hospital)	105	0	0
Examination fees, registration, etc.	49	0	0
Instruments, anatomical dissections, books, etc.	50	0	0
Plain clothes (renewal of), washing, etc.	50	0	0
Board and lodgings (allowing for holidays, etc.)	200	0	0
Examination for entrance into Navy	1	0	0
Details not recollected	40	0	0
	£596	0	0

This parent adds : "In each case I do not include cost of uniform for entry as a commissioned officer, though anyone can see that the cost for the engineer, due to the rough usage in connection with machinery and duties generally, must be more than the cost to surgeon for his walk to the sick bay a few times a day."

These figures are, of course, subject to a little fluctuation, according to the views of parents as to what is necessary, but this would not affect their proportions.

Another letter in the *Naval and Military Record*, same date, says: "A doctor in the service sent a friend a copy of the *Lancet* (the Students' number), in the editorial of which the writer states that for £400 a boy could graduate." It could be done for even less.

Executive Branch.

Now let us glance at the cost of training in H.M.S. "Britannia," and until independent. Boy enters 14½ to 15½, average 15).

	£	s.	d.
Entrance examination	1	0	0
Fees, four terms at £25	100	0	0
Outfit at start	50	0	0
Plain and underclothing for five years	50	0	0
Books, stationery, instruments, sextant, etc.	45	0	0
Annual expenses, washing, renewals of uniform and plain clothes, etc., for four years at £40 per annum	160	0	0
Allowance of £50 per annum, compulsory, for 3¾ years after leaving "Britannia," till rank of Sub-Lieutenant is attained	187	10	0
	£593	10	0
Deduct one year's schooling, from 15 to 16, which the Engineer Student, Doctor and Paymaster have to pay ...	100	0	0
	£493	10	0

Paymaster's Branch.

Expenses of clerks entering the Navy on same scale as preceding estimates. (Over 17, and under 18).

	£	s.	d.
One year extra at school	100	0	0
Examination fees	2	0	0
Possibly one half-year, if not passed at first trial	50	0	0
Medical examination, and expenses to London and back for same	10	0	0
Allowance by parent for first year till appointed assistant clerk	20	0	0
	£182	0	0
Deduct from this –			
Pay from 18 to 19 ... ... £45 12 0			
Pay from 19 to 20 ... ... 73 0 0 ...	118	12	0
	£63	8	0

Parents are only out of pocket, £63 8s.

APPENDIX B.

Descriptions of the Machinery of Typical British Warships.

The steam screw frigate, H.M.S. "Agincourt," was built about 1865. Her engines were of the horizontal cylinder return connecting rod type, the 2 cylinders being each 101 inches diameter, with 54-inches stroke.

The steam was supplied, at a pressure of 25 lbs. per square inch, by 10 rectangular return tubular boilers, having 40 furnaces.

Her nominal H.P. was 1,350, but on her trial trips her engines developed 6,867 I.H.P. at 61½ revolutions per minute.

The engines were very heavy, and were fitted with jet condensers.

The auxiliary engines were only 3 in number.

There was no mechanism in connection with the armament.

The first-class twin screw battleship, H.M.S. "Vengeance," has a displacement of 12,950 tons, and is fitted with 2 sets of triple expansion engines, which are capable of developing 13,500 total I.H.P., with natural draught.

The maximum speed of this vessel is 18 knots per hour.

The cylinder diameters are 30 inches, 49 inches, and 80 inches respectively.

The stroke is 51 inches, and the engines run at 108 revolutions per minute.

The steam is generated at a pressure of 300 lbs. per square inch by 20 Belleville water tube boilers, fitted with economisers, and is reduced at the engines to 250 lbs. per square inch.

The auxiliary machinery, consisting of 78 engines, is as follows :—

2 Starting engines.	2 Turning engines.
4 Main circulating engines.	2 Auxiliary circulating engines.
2 Hotwell engines.	6 Feed engines.
4 Fire engines.	1 Workshop engine.
5 Furnace air pumping engines.	4 Distilling engines.
3 Dynamo engines.	2 Steering engines.
4 Air compressing engines.	2 Boat hoist engines.
2 Refrigerator engines.	1 Drain Tank engine.
2 Capstan engines.	2 Coal hoist engines.
5 Ash hoist engines.	8 Ventilating engines for ship.
2 Ventilating engines for engine room.	6 Ventilating engines for boiler room.
3 Hydraulic pressure steam engines.	4 Hydraulic engines for barbettes.

The armament consists of four 12-inch and twelve 6-inch guns, and about thirty-eight smaller guns, including Maxims, and two submerged torpedo tubes.

This ship carries 3 steam-boats and 19 torpedoes.

Exclusive of the 2 sets of main engines and their direct driven air pumps, the chief engineer has under his charge, 78 auxiliary engines and machines, the machinery of 3 steam-boats, 2 submerged torpedo tubes, and 19 torpedoes, together with the mechanism of the whole of the gun mountings and the innumerable water tight doors and compartment, flooding and pumping arrangements fitted throughout the ship.

The first-class cruiser, H.M.S. "Terrible," has a displacement of 14,200 tons, and is fitted with 2 sets of triple expansion engines developing 25,000 total I.H.P. with natural draught, and propelling the ship at a maximum speed of 22 knots per hour.

The diameters of the high and intermediate pressure cylinders are 45 inches and 70 inches respectively, and there are 2 low pressure cylinders each 76 inches in diameter. The stroke is 48 inches, and the engines run at 112 revolutions per minute.

The steam is generated at a pressure of 260 lbs. per square inch, by 48 Belleville water tube boilers, and is reduced at the engines to 210 lbs. per square inch.

The auxiliary engines and other machines, exclusive of armament mechanism, are 93 in number, viz :—

6 Main feed engines.	18 Fan engines.
8 Auxiliary feed engines.	4 Air-compressing engines.
4 Main circulating engines.	1 Refrigerating engine.
2 Auxiliary circulating engines.	12 Ash hoist engines.
2 Hotwell pumps.	2 Coal hoist engines.
4 Fire and bilge engines.	2 Boat hoist engines.
2 Reversing engines.	1 Workshop engine.
2 Controlling pumps for feed engines.	2 Turning engines.
2 Steering engine .	12 Air furnace engines.
3 Electric light engines.	2 Capstan engines.
2 Evaporator pumps.	

The armament consists of two 9·2-inch, twelve 6-inch, eighteen 12-pounder, and a number of smaller guns and Maxims, and four submerged torpedo tubes.

The armoured cruiser, H.M.S. "Drake," which is now building, will have a displacement of 14,100 tons and a total I.H.P. of 30,000 when working with N.D. Her speed is to be 23 knots per hour.

The torpedo boat destroyer H.M.S. "Mermaid" is a representative specimen of a batch of 12 new boats.

Her displacement is only 320 tons, but she is fitted with twin screws driven by 2 sets of triple expansion engines, each 19 inches, 29 inches, and 46 inches by 18 inches stroke, developing under F.D. no less than 6,541 total I.H.P. when running at 400 revolutions per minute.

Under these conditions, the speed attained on the measured mile was 30·98 knots per hour, and the speed maintained during a 3 hours' run was 30·833 knots per hour.

Her auxiliary machinery, consisting of 18 engines, is as follows :—

2 Circulating engines.	1 Electric light engine.
4 Feed engines.	1 Distilling engine.
1 Bilge engine.	1 Capstan engine.
1 Steering engine.	2 Starting engines.
1 Air-compressing engine.	4 Fan engines.

The torpedo boat destroyer, H.M.S. "Express," now building, is to be fitted with engines capable of developing 9,250 I.H.P. under F.D. conditions.

APPENDIX C.

Statement of the Changes in Organisation, &c., which the Engineer Officers, Royal Navy, consider necessary to place their department upon an efficient footing.

The Engineering Branch of the Royal Navy.

The engineer officers of Her Majesty's fleet consider it their duty to make known to all those interested in the efficiency of the Navy, the intense dissatisfaction prevailing amongst them with regard to the unduly subordinate position their department holds in that service.

This dissatisfaction is of long standing, affects all ranks and ratings, and, owing to the development of modern ships of war, leads those officers who are responsible to entertain grave doubts of the ability of their department to bear the stress to which it must be subjected during actual warfare.

The Causes of dissatisfaction are :—

1. Engineer officers are still classed as a civil branch of the Navy. They have no executive control in their own department, and have no power to award even *minor* punishments.

The officers are not permitted to sit on courts martial when an officer or man of the engine-room department is being tried for departmental offences.

2. The rank held by these officers is, age for age with the executive branch, unsatisfactory, considering their great responsibilities. The numbers of officers, too, in the highest ranks of these branches is disproportionate, as there are only 14 engineers out of a total of nearly 900 ranking with captains, who number 189 out of a total of 1,786 commis-

sioned officers of the executive. There are also 65 flag officers on the active list, with the most junior of whom not one engineer officer has equal rank. There is, therefore, an officer of or above the rank of captain for every 7 commissioned executive officers, whilst in the engineering branch there is but one of captain's rank for every 69 engineer officers.

3. The engineering branch has not a single representative on the Admiralty Board, notwithstanding the fact that it has a *personnel* of about 25,000, and responsibilities in connection with nearly the whole of the *matériel*.

4. The pay of these officers generally, more especially on promotion to the rank of "engineer," and while serving in that rank, is quite inadequate.

5. The compulsory retention of engineer officers beyond the age of 50 is detrimental to the interests of the service, and causes a serious block in the promotion of officers from the rank of "engineer."

6. Engine-room complements are too small to carry out the work of the department under high rates of steaming, or under such stress of circumstances as may be expected during war time.

7 Writers are not allowed to the chief engineers of H.M. ships, consequently highly trained officers have to be employed for merely clerical work. There is no regulation which ensures that specially suitable persons for charge of engineers' stores shall be included in the engine-room complements.

8. Stokers are not granted re-engaging pay as is now given to the seamen class.

Engineer officers are agreed that the following remedies would greatly increase the efficiency of the Navy:—

1. A corps of Royal Naval Engineers should be formed, and classed as a military branch of the Navy, the officers being executive in their own department, and administering *minor* punishments in it.

On board ship the senior officer of the R.N.E. corps would be responsible for the discipline and conduct of his staff to the captain direct. The engine-room ratings in the Naval depôts would be under the entire charge of the Royal Naval Engineer officers, who would be solely responsible for the training and distribution of their men.

An officer of the R.N.E. corps to sit on courts martial when an officer or man of the corps is being tried for departmental offences.

2 & 3. The titles and mode of promotion to be :—

Titles and Age.	Corresponding Age of Deck Officers.
Cadet, R.N.E., 16 to 21	Cadet and Midshipman, 14½ to 19.
Sub-Lieutenant, R.N.E., 21	Sub-Lieutenant, 19.
Lieutenant, R.N.E., 24 to 25 ... ... (To commence counting senior time).	Lieutenant, 19 to 22.
Lieutenant of 8 years, R.N.E., 32 to 33	Lieutenant of 8 years, 27 to 30.
Commander, R.N.E. (No. kept at 200)...	Commander (by selection).
Captain, R.N.E. (by selection)	Captain (by selection).
Rear-Admiral, R.N.E. (5 in number) ...	Rear-Admiral (by rotation).

Officers of the R.N.E. corps to rank *with* the deck officers according *to* date of commission, with uniform the same as now worn by those officers, but with distinction cloth.

The engineer-in-chief to rank as Vice-Admiral. An engineer officer to have a seat on the Admiralty Board.

The number of captains, R.N.E., to be 25—For service at the Admiralty, in the fleet and dockyard reserves, the dockyards, depôts, Royal Navy Engineers' College, &c.

4. A parliamentary committee to be appointed to enquire into, and adjust, the pay and retirement of the officers of the R.N.E. corps.

5. Officers of the rank of Commander, R.N.E., to be permitted to retire at the age of 50.

6. The complements of the engine-room departments in H.M. ships to be increased, until a condition of safety has been attained.

7. A writer, recruited from the department, to be added to all engine-room complements. A definite rating called (for example) "Yeoman of Stores" to be established, similar to that of stoker-mechanic, with an allowance while serving in that capacity.

8. Stokers to be granted re-engaging pay, as now given to the seamen class.

Explanatory :—

Naval engineer officers are of opinion that in consequence of the enormous increase in their responsibilities, more especially in the event of war, the time has now arrived for their position on board H.M. ships to be strengthened, and their full value *officially* recognised, so that they may be able to perform their duties in a manner worthy of the best traditions of the service.

The engineer officers are convinced that the best way to achieve this result would be by the *formation of a separate Corps of Naval Engineers*, by levelling up the rank of officers, and by adopting executive titles indicative of the executive nature of their duties.

The habit of command and proper control by the engineer officers of their subordinates is actually hampered by the present constitution of

the engineering department, which does not permit these officers to assume any executive authority over their men, nor give them the power to reward merit and punish misconduct. This want of power is more especially felt when the offences are of a technical nature connected with matters relating to machinery or the duties of the engine room, the gravity of which can be best appreciated by the officer in charge of the engineering department. The engine room ratings never feel that their own officers have any power over them which can compare with that exercised by the deck officer, who is frequently a perfect stranger to them until they are—according to the rules of the service—brought before him by the engineer officer for some irregularity demanding investigation and necessary punishment. This absence of direct control on the part of these officers undermines their self-confidence, and has its reflex action on the men, who are always quick to notice any signs of inferiority in the status of their departmental officers. They, therefore, cannot be expected to acquire the proper feeling of respect for the officer who is so little trusted that he cannot be allowed even to award minor punishments for offences committed almost immediately under his own eyes and in his own department. It is important to remember that the whole of the men of the engineering branch join the Navy at an adult age; they go to sea without any previous acquaintance with their duties, and have not had the opportunity of acquiring during their youth those habits of order, discipline, and strict obedience which are so valuable a feature in the training of the seamen class who enter the training ships as boys. In all newly-commissioned ships at least one-third of the stoker complement consists of these raw recruits, while of the remaining two-thirds many are frequently of scarcely more than one year's service.

The necessity for executive rank in the engineering branch was recognised as long ago as 1876 by the committee presided over by the late Admiral Sir A. Cooper-Key, which, after an exhaustive inquiry, recommended "that the engineer officers should be classed with the executive or military branch among those who would not on any occasion succeed to command." If such a change were necessary then, how much more so is it at the present day ?

The naval engineer holds *relative* rank only, and in many grades his uniform—the outward sign of the estimation in which he is held—advertises his inferior position, and tends to weaken his authority in the eyes of his subordinates. The officers of the rank of "engineer" may be quoted as an example of this. Many of these officers (over 100 at the

present time) are performing the duties of "chief engineer" in various small vessels, principally the "destroyer" type, where the horse-power is, in some cases, as high as 10,000; yet it will hardly be credited that a large number of them have rank to *with*, *but after*, the most junior lieutenant or surgeon, and, in addition, advertise this fact on their uniform. It is a fact that these officers cannot attain, until 11 years after the completion of their training, the rank and pay that a medical officer is granted on entering the service. Can it be wondered at that, with their great responsibilities and lack of official appreciation, this particular grade of naval engineer is very discontented.

Further, at the Admiralty, the headquarters of the largest steam fleet in the world, the head of the engineering branch is not admitted to the councils of the Admiralty. Surely, with the experience that has recently been gained, it is time that an engineer officer of high rank had a seat on the Admiralty Board itself.

The duties of a naval engineer in H.M. ships at sea are (especially during his junior service) of a very trying description physically, and the result is that by the time he arrives at the age of 50 the average officer would be quite unfitted to stand the immense strain which modern warfare would entail. Another reason for permitting optional retirement at 50 years of age is to facilitate the flow of promotion among the junior ranks, in which at the present time there is a most serious block.

In submitting this statement the engineer officers do so with an earnest concern for the efficiency of their department. It is with them no question of a desire to diminish in any way the authority of the executive; in support of which statement they feel justified in referring to the loyal and zealous performance of their duties under many disabilities as a comparatively new branch of the Navy, and amid the trying conditions incidental to the rapid development of engineering for war-ship purposes. These officers maintain that, in accepting the responsibilities of their position in their country's defence, they deserve equal honours with the other branches of the fighting services.

The engineer officers unhesitatingly submit that the marks of inferiority which have for so long been the bitter portion of their profession should be removed, so that they may be proud of belonging to the Navy, and of the uniform they wear. They are convinced that nothing short of a full recognition of the value of the engineering department, and its complete re-organisation, will enable it properly to fulfil its onerous functions, on which the efficiency of the British Navy must so largely depend.

DISCUSSION.

The VICE-PRESIDENT said he had to state before proceeding with the discussion that both Mr. Morison and the Secretary had received a number of communications from some well-known people, and he would like to know if it was their wish that these communications should be read. The Secretary had one from Sir Fortescue Flannery, another from Mr. Jas. M'Kechnie, of Barrow-in-Furness, and Mr. W. Brown, of Woolwich.

Mr. MORISON: I have also about a hundred.

On the motion of MR. WESTGARTH, the communications were remitted for publication in the *Proceedings*.

March 28th, 1900.

DEAR MR. DUCKITT,

Thanks for your letter of yesterday kindly conveying to me the courteous invitation of your Council to attend at the meeting on the 30th inst., for the purpose of joining in the debate upon Mr. Morison's paper, on "The Position of Engineers in the Royal Navy." I greatly regret that my duty in Parliament makes it impossible for me to leave London this week, otherwise I should have had much pleasure in attending.

I have carefully read the proof of Mr. Morison's paper, and am glad to find that it deals worthily and comprehensively with so important a subject. The question of the position of the engineers in H.M. Fleet is not one pertaining to the engineers alone; it is a national question, affecting the efficiency of the fleet upon which the very existence of Great Britain as a nation depends. The concessions granted by the Admiralty recently to engineers are in the right direction, but they do not go far enough. What is required is that the engineers should not be mere officials or scientific assessors, ranking in power and authority with the chaplain and the surgeon and the paymaster, but that they should be officers in reality, with proper authority to ensure discipline amongst the men nominally under their control. The chaplain, the surgeon, and the paymaster have no responsibility for the efficiency of a department or for numbers of men. The engineer, whose authority is no greater, has responsibility frequently for the greater portion of the ship's company, and still his orders are given on sufferance and without

the power of executive control vested in the most subordinate sub-lieutenant, or even the junior midshipman. Successive committees appointed by the Admiralty to consider this question have arrived at conclusions that the engineer should be an officer in fact, and in rank and in title, and not merely a civilian as he is at present. But although those committees have been appointed with presumedly the intention of acting upon their reports, these reports, when found by the Admiralty to be in favour of executive control to the engineers, have been ignored. The latest investigation was one held, by the orders of the present Board of Admiralty, by Mr. Macartney, M.P., the secretary of the Admiralty, Admiral Douglas and Captain Prince Louis of Battenberg, and their report was in favour of forming separate corps and giving the engineers executive rank. I challenged the First Lord of the Admiralty on this report in the House of Commons recently, and this fact was not denied, nor was any attempt made by the Admiralty to justify its departure from the recommendations of its own recently appointed committee, two members of which were executive sailor officers and the third member a civilian, entirely unprejudiced in favour of engineers, and all of them capable of approaching this question with unbiassed minds.

The reform must come, and, if in addition to the efforts being made in Parliament, societies throughout the country of such an influential character as your own will discuss, and agitate, and pass resolutions to be forwarded officially to the Admiralty, and to the members of Parliament representing maritime districts, the day will be hastened when this necessary and highly important change will be effected; leading, as we all patriotically hope, to the complete and thorough efficiency of H.M. Navy.

Yours faithfully,

FORTESCUE FLANNERY.

VICKERS, SONS, & MAXIM, LIMITED,
NAVAL CONSTRUCTION WORKS, BARROW-IN-FURNESS,
March 29th, 1900.

DEAR MR. DUCKITT,

I have to acknowledge receipt of the advance proof of Mr. Morison's paper on "The British Naval Engineer, his Present Position and Influence on our Sea Power," and in reply to your request I herewith enclose a few notes on the subject.

Yours faithfully,

JAMES MCKECHNIE.

My close association with naval machinery and naval engineers has compelled me to take a deep interest in the subject with which Mr. Morison has dealt so ably in his paper, and as I have been asked to say something I avail myself of this means of agreeing with many engineers in the strong opinion that some amendment is desirable in our naval engineering system. A note for reform has been stated in a comprehensive way by the author of the paper. He has not omitted any point; indeed, he has even made one uncomfortable by the dark, lurid coat he has painted over us in the possible collapse on the next serious call on the naval engineer. I am not, however, one of those who take the pessimistic view which may be promoted by Mr. Morison's paper, although probably quite unintentional on his part. Experience advises confidence in the resources of the naval engineer, young as he may be, for he has received a good training either at the Keyham establishment, so ably conducted by Mr. Mayston, or in some of our private engineering establishments; but while we discourage such pessimism it is equally important that we should make every effort to have undoubted grievances redressed, because the naval engineer is certain to act with the pluck and grit which has ever characterised his race. The nation has no right to exact duties which are too onerous, without giving him even the credit or the reward. A great change has been made in our ships of war by the advances of mechanical engineering. Wars will be fought and won as much by the watchfulness and resource of the engineering staff as by the strategetic skill and accurate fire of the fighting staff. The increasing importance given to steam machinery even in our battleships, which are no longer slow moving, fighting batteries, but high speed nineteen knot line of battle cruisers is undoubted, and yet the relative status of executive and engineer officers is continued without change. The executive officer has the same position as when there was no engine in the ship and the engineer is without rank—he is indeed without official status. As this new element in naval power is as important as firing the guns or navigating the ship, the personnel having charge of it should logically be recognised as clearly. Again, the adequacy of the staff should be as jealously promoted. Engineers specially recognise the importance to the Navy of this matter, and here I would strongly urge that our advocacy should go forth on this basis rather than as a piece of special pleading for the naval engineers because they happen to be members of our Institution or of our profession. I know I will not be misunderstood in thus differentiating between the national cause and the personal element—much has been lost in this way

and more by injudicious reasoning and extravagant claims, and I strongly urge that these should be guarded against in any step to be taken by the Institution. The advocates of naval engineers in the House of Commons and in the Press have not always acted with discrimination. The spirit of exaggeration has been too pronounced, and if action is taken by the Institution I think the preferable course would be to arrange for a strong representative deputation of engineers, selected by our Institution in conjunction with the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Shipbuilders and Engineers in Scotland, and the Institution of Naval Architects to wait upon the First Lord of the Admiralty and formulate a reasonably moderate reform, which could be supported by incontrovertible arguments of national moment. I am persuaded that the views thus enunciated of those who build and engine the ships of war would have great weight with Mr. Goschen, who has ever shown such a strong desire to make the Navy invulnerable and its administration perfect. Precision as well as moderation must be practised in the formulation of the reforms. It is just possible that owing to the variation in the demands as well as in their extravagance the aims of the friends of the naval engineers have been defeated, but I would advise the committee or deputation to ascertain the state of the case in other navies. I am informed that in Russia every officer, engineering as well as executive, has the right to punish the inferiors in his department, and prohibition to do this is one of the grievances of our engineers. Again, it is surely not beyond the wit of man to devise a system of rank which would satisfy the engineers and yet not interfere with the executive staff. Mr. Morison points out the dearth of applicants has apparently rendered it necessary to introduce engineers from the private workshops in the country, and points out that this is likely to increase in the future. This I think might be made a satisfactory system, and as there is something in his argument that such men lack the discipline which drilled training confers, I would suggest that it should be a condition that men thus admitted into the Navy from private works should have served a certain period of years either in the rifle or artillery, or naval volunteers. On page 187, Mr. Morison gives a list of the duties and responsibilities of the naval engineer. This should be supplemented by the statement that transferable mountings and deck torpedo tubes are under the joint charge of the engineer and the gunner and torpedo lieutenants, while all the electric motors are under the charge of the torpedo lieutenants. This means that stokehold fans driven by electric motors would be under the

charge of the torpedo lieutenant, while the boilers themselves would be under the charge of the engineer. Here we have an overlapping and interchange, which seems to indicate that to refuse to recognise the engineer as a combatant officer and to grant him rank is inconsistent; but I have already said enough and hope that some effective action will be taken which will ensure that the First Lord of the Admiralty will have placed before him the views of the naval engineering constructors, who are the citizens best qualified to form an opinion on this question of great national importance.

WOOLWICH,
March 28th, 1900.

DEAR MR. DUCKITT,

The proof of Mr. Morison's paper has just come into my hands and I hasten to offer a few remarks without having read the proof, and I trust that Mr. Morison's paper will be the means of calling further attention to the status of the most valuable branch of H.M. Navy.

Having almost continuously been in touch with the engineering branch of H.M. Navy for twenty years, I have had every opportunity of judging of their qualifications as engineers and cannot speak too highly of them as a branch of the service.

Seeing that the engineer of a warship has both hull and machinery under his charge so that the modern fighting ship is an engineers' domain in every sense, it is quite time that the engineer-in-chief should have a seat on the Board of Admiralty.

The dearth of engineers in the Navy is greatly owing to the stiff examination in mathematics and as only a very few of those who pass this examination have an opportunity afforded them of being appointed to the designing department at the Admiralty, a great proportion of those who have worked hard and got well up to the top of the list are disappointed.

I feel sure that many who fail under present conditions would have made very good practical engineers, and that is the class of officer who is required on board a vessel going away on a foreign commission. With the mathematical standard altered I feel sure that a sufficient number of young engineers of high mathematical attainments would be found from which to select designers, as only about 15 per cent. of those entered into the engineering branch of the Navy are thus required.

I do not know if any course of instruction is given to the young engineers with a view to anticipating repairs in cases of breakdowns at

sea, but I think the clear demonstration of an effective and smart repair is of infinitely greater value to the majority of the students than an abstruse mathematical problem.

The appointment of engineers instead of chief engineers is a proof of the scarcity of senior officers in the engineering branch of the service, but I will not say that it is wrong to appoint an engineer in lieu of a chief, for it must be remembered that to be able to enter the Navy an applicant must be no fool and that by the time he has reached the rank of engineer he may have had a great deal more experience than an engineer in the merchant service who has put in sea time enough to pass the Board of Trade examination as chief; and I do not for one moment believe that these appointments are made without very careful thought and enquiry into the past services of the engineer thus appointed to the chief's duties.

With respect to the pay of the engineering branch of the service this is in my opinion a subject for very serious consideration. This officer must keep up his position as such at sea, his family must live up to his position at home, and his children have to be educated; and all this at the time when his pay is very inadequate. At present he gets the higher remuneration when his family is grown up and the opportunity for ever lost of giving his children an education which would have ensured (in all probability) the sons following the same profession as their father, and this latter is an object at which our naval authorities should aim.

On the first of April, I believe, a re-arrangement of pay is to be made in this branch of the service, and so far as I can see it is about equal to a payment in money fresh from the mint instead of with the coppers now in circulation.

Yours faithfully,

WILLIAM BROWN.

Mr. E. G. GEARING, opening the discussion, said there could be no two opinions as to the value of Mr. Morison's paper, or the thanks due to him for the time and trouble he had taken to bring this important and difficult subject before them It divided itself into two parts, the engineering and social; and, moreover, bristled with difficulties, the measure of which could be judged by the time it had taken, and the slowness with which any alteration had been made. As they must concede, the various Governments that have been in power during the last 30 years could not have been so unpatriotic as to wilfully leave this vital question unsettled, and still practically in the state they all found

it; therefore, there must be some reasons besides the natural inertia of men, who having held the reins so long were disinclined to let others take hold. He thought they might take it that the engines during an actual action would be required to work, as far as they only were concerned, under trial trip conditions. By this he meant that the maximum power must be available, and the engines be ready to be handled promptly at the command of the executive branch. Two men at least would be required to be standing by, that is, one for each engine, if not more, and no doubt the whole of the engineering staff would be on duty. Even at this, from his own experience, he thought the men were perilously few for the mass of machinery in their charge. Assuming the action to be successful—otherwise of course, it would not matter—the men would be more or less necessarily exhausted from the natural anxiety, and the high temperature prevalent in the machinery department of many warships, and if any further pursuit was necessary, it could not be kept up for many hours before it would inevitably lag through the exhaustion of the staff in the engine-room itself. For powers such as were now in modern warships, namely, 16,000 to 20,000 horse power with twin screws, his experience had been that at least two engineers were constantly required in the engine-room, and one at least in charge of the stokeholds; and another to take charge of the pumping power of the ship to see that she was properly drained of water, but of course practically attending to both engine and boiler rooms. Besides these an electrician must always be on watch, and where there were installations of hydraulic or other power another engineer was almost a necessity; and if it was correct that in ships such as the "Mars" and our fast-armed cruisers there were only 1 engineer and 4 assistants, with 3 engine-room artificers, and 9 others, making a total of 16 without the chief, it was impossible to efficiently work this machinery for any length of time without serious risk of breakdown. Divided into two watches would give 8 men on watch with the chief having the oversight, and assuming that these were all thoroughly experienced men, capable of taking charge of a watch—which by the age of some of them and their experience, did not seem at all probable—they would be able to keep the machinery going no doubt for a day or two, but if the demands upon the steam power previous to action—which of course in the chase of the enemy or otherwise would be very severe—were considerable, it seemed an utter impossibility to him to keep the ship at full speed without very shortly exhausting the whole of the engineering staff. Many of them knew the utter demoralisation which soon set in in trying to run modern

high speed machinery with exhausted men. As to the stokeholds, in his experience he had found that under trial trip conditions, with men changed each 2 hours, each man was capable of throwing one ton of coal per hour into the furnaces. This required in an ordinary mail steamer another man to procure it for him. With the complication that must necessarily occur in the bunkers of a man-of-war, owing to the subdivision, he thought at least another man would be required. For ordinary purposes, steaming say up to one week, one man could throw into the furnace during an ordinary four hour watch with eight hours rest between, 15 cwts. of coal per hour. This required also one man to procure the coal from the bunkers ; and in a warship two at least would be required. Dividing the number given for a battleship into two watches there would not be so much cause for anxiety as there was in the engineering departments ; but if many of these men were taken for deck purposes, as he knew they were liable to, steam would very soon be irregular, and the engines difficult to keep anywhere near their average sea power. He did not think three men would keep one man sufficiently supplied. He had been on board a ship burning 350 tons of coal per day, and they could have burned more if they could have got it. If they steamed eight hours full steam on board a warship, they needed a lot of men to get the coal out. There was an undoubted case made out for reform, but of course the difficulty of keeping these large staffs on board ship when only steaming at reduced powers—which occurred the greater part of a warship's life—was a great one, but it appeared possible to arrange a system whereby the grades might be kept something like as at present, but being able to expand the different sections. He did not mean to say that they could have a peace navy the same as a peace army ; but if it were possible, they should have a department capable of expansion. He did not think the country would expect a peace complement to be the same as the war complement. He thought, however, they should have an organisation with so many men for peace purposes, which could be extended at once. Perhaps there was such a scheme stowed away somewhere. It did not seem a difficult thing. He admitted the difficulty in that they had not got the men ; but surely they could be secured. He thought that each ship's war crew in the engineering department should be arranged beforehand, and probably this had been done, and the papers with the chief engineers, who would have so many assistants, artificers, chief stokers and leading stokers, and other ratings, which should be increased on the declaration of war at once to the grade of war strength. Of course the difficulty of this is that there

is not a sufficient number of men borne on the books of the Navy to enable this to be done. As to the social side of it, there was in his opinion an undoubted grievance as to the relative rank of the executive and the engineering staff, which, although it might be called sentimental, existed and seriously impaired the efficiency of their first line of defence. Any engineer who had been to sea, even in the merchant marine, felt the reflection of this from the naval branch. It was not necessary, however, to enlarge on this, as Mr. Morison had very fully gone into the matter.

Prof. WEIGHTON, M.A., said that personally he looked upon it as a duty that as a member of this Institution and a citizen of this country, one should express an opinion upon the points raised in Mr. Morison's paper. First of all he thought they owed a debt of gratitude to the writer for undertaking the work of preparing such a paper, and for the fearless and open expression of his opinions. There could be no selfish or commercial motive involved in this case. As he understood the writer's object, he had solely and exclusively the efficiency of the British Navy at heart. He believed this efficiency to be seriously threatened by a defective system connected with the engineering department, and he asked for the expression of the opinion of marine engineers on the subject. He (Prof. Weighton) could not but think that such a matter was peculiarly suited for being dealt with by an Institution of Engineers and Shipbuilders. Looking broadly at the subject the first thing which struck him was that there was deep and wide-spread discontent amongst the engineers in their Navy. This of itself constituted a *prima facie* case for enquiry by a competent tribunal. But this aspect of the case was only a comparatively trivial circumstance. This was not a question of justice to any class or section (though of itself even that was of considerable importance); this was a question of the fighting efficiency of machines, whose peculiar and special object it was to *fight*. If the facts and figures given in the paper were correct (and he saw no reason to doubt their accuracy, as he believed they had been very carefully compiled) then he thought the causes of dissatisfaction amongst naval engineers were not far to seek. And he hoped the members of the Institution would at least put on record their views, firstly, as to the sufficiency in *number* of responsible engineer officers carried in typical ships such as those mentioned in the paper, and secondly, on the conditions under which these officers performed their duties. It seemed to him that the second was of even more importance than the first, though it was difficult to decide as to the relative importance of the two. The

paper gave many instances of the humiliating conditions under which the naval engineer works. What could be more subversive of discipline than the system which held the engineer responsible, and yet denied to him the power of dealing out rewards and punishments amongst his own men, compelling him to go before an executive officer possibly many years his junior? What could be more detrimental to efficient management, which was always willing and cheerful management, than the arrangement by which educated specialists might be tried, and possibly condemned, by a court martial composed entirely of deck officers, whose ignorance of engineering technicalities was profound? Then again he would ask, "Was it the case that the engineer officer had to serve eleven years before he was eligible for the same rank and pay as the medical officer got at once? And if so, what could possibly be the justification for such a regulation? Men responsible for the efficient maintenance of modern war vessel machinery were not mere engine drivers or mechanics. They were—or ought to be—educated experts, and as such they deserved treatment accorded to their class in civil life. And the fear was that unless they got such treatment the efficiency of the Navy would suffer, and suffer seriously.

Mr. T. WESTGARTH said it appeared to him that the subject of the paper was of Imperial concern, and probably they were all Imperialists now. He thought it was sometimes overlooked that not only the engineers and other officers of the Navy were the servants of the country, but that the Admirals and the Lords of the Admiralty were also the country's servants. They were members of an honourable profession and they honourably fulfilled their duties; but they were paid for it, and paid by all of us. Surely, if they mismanaged the business the public had a right to object, and Mr. Morison had, in his opinion, done a public service to Great Britain in showing that great changes were necessary. Experience had taught us how great was the influence of public opinion upon state departments. Look what public opinion had done in the matter of the conduct of the present war. The war began badly and disastrously, and not till public opinion was heard through the Press did those who were in authority begin to conduct the war properly. That was an object lesson, and should support us in bringing pressure to bear upon those at the head of the Navy. Mr. Gearing said he thought it would not be difficult to arrange for some reserve. He (Mr. Westgarth) wished it were as easy as Mr. Gearing thought. No doubt it would be easy on paper, but there was

no material ready. It was pointed out in the paper that in case of an emergency mercantile marine engineers could not be found, because they would not be suitable. That reflected no discredit upon the engineers of the mercantile marine—a splendid body of men—but those acquainted with naval work would understand that if a mercantile engineer were placed on board a warship, it would take not only weeks, but months before he would be able to take charge of a watch. He would be quite at sea in regard to the complications crowding about him, nor would he readily appreciate the discipline, the method and manner on board a warship. It was said that the engineering branch of the Navy was not popular. He did not wonder at that; he did not think any of them would go into the Navy if they could avoid it. He was sure he would not after what had been heard that night. The regulation that naval engineers should not be able to communicate with the engineer-in-chief, except by reports to be re-written by the captain, was harsh and apparently unreasonable. Another real grievance was the unsatisfactory arrangement as to rank. Surely the claims of the engineers were as reasonable as those of the executive officers. Again, the arrangements as to minor punishments awarded to members of the engine-room staff were bad and certainly not calculated to uphold the authority of the engineers over their men; they all knew if they did not give power to their foreman to set on and dismiss his men he had no authority at all, and if worth anything he would not accept such a position. Why should not the naval engineers have the same powers? It was evident by their numbers there that night that they believed the subject was worthy of consideration and discussion, and it was quite evident from the way they listened to the paper that they approved in the main with the views expressed by Mr. Morison. He begged of them whatever they did that night, not to let the whole thing evaporate in waste steam, but let them have some result from the excellent paper and large meeting. He thought Mr. Morison's suggestion that a committee should be formed was an excellent one, and he hoped the Council would receive it as a strong expression of the wish of this meeting that a committee be formed on the lines suggested by Mr Morison.

Mr. F. T. Marshall thought they were all thoroughly agreed upon the extreme importance of the very comprehensive and interesting paper Mr. Morison had read to them. It dealt with a subject of the very highest national importance, and, as Englishmen, he thought they were all deeply interested. Mr. Morison had really put the case so very fully

on all the points connected with the naval engineers' position that there was very little else to say. It was, indeed, monstrous that engineers should be put in this very subordinate position. He had had considerable experience of naval engineers, and it always seemed wonderful to him that they had the control over the engine-room complements which they had without other executive authority. If they had such authority he thought there would be little to be desired in the engine-room discipline.

With regard to the question of pay, it should be at least equal to that of the executive officers, and that the engineering branch of the service should be represented on the Board of the Admiralty, and also on courts martial, was, he thought, only a very reasonable request in face of the number and importance of the engine room personnel.

With regard to the paper generally, and of the present efficiency of the engineering branch of the Navy, he thought Mr. Morison was a little pessimistic. In his comparison of numbers of engineers in H.M. ships and various liners, he seemed, in his opinion at all events, to have taken but little recognition of the staff of engine-room artificers, mentioned in another part of the paper as the backbone of the engine-room complement. All of them, if in the mercantile marine, would be classed as engineers, and most of them would be possessors of Board of Trade certificates. If they added the engine-room artificers to the commissioned officers, then the number of mechanically trained men in the engine-room service became about equal in the liners and warships. No doubt, owing to the special conditions of the warships, there was an urgent necessity there for commissioned officers, and the present was not the only thing; they had also to look to the future. Within a very few years their line of battle-ships had increased in natural draught power from the 10,000 I.H.P. of the "Majestic" class to 18,000 I.H.P. of the "Duncan" class; in cruisers, the last first-class cruisers with cylindrical boilers developed with natural draught 10,000 H.P. in the "Edgar" class, and this was being increased to the 21,000, 22,000 and 30,000 H.P. of the "Cressy," "Monmouth" and "Drake" classes respectively. These later ships would require more officers than the ships they would replace, and it seemed to him there was a very urgent case for immediate action. With regard to the commissioned ranks, it was very difficult to see how it could be done, but he thought public opinion should be brought to bear upon the subject in some form.

With regard to the question of reserve that Mr. Westgarth mentioned, he thought there was a certain class of men who might occupy this

position in a national emergency, who would make at least very efficient artificers, that was the mechanics constantly employed in the fitting on board of warship work. There were ten or twelve firms in the country constantly doing warship work; large staffs, many of them with 100 mechanics, not only craftsmen but fitted to take charge of the steaming of the machinery of all kinds of warships, from battleships to destroyers. These men would, he was sure, on an emergency be available for the country's service.

He thought they owed a great deal to Mr. Morison for the prominent way he had brought the whole matter forward, and thought some definite action should certainly be taken. In what form it was not for him to say. A most interesting development had recently taken place in the American Navy in this matter of engineer officers. He noticed Lieutenant Norton with them that night, of the U.S.N., and if he would give them some information about the development which had recently taken place in the States he (Mr. Marshall) thought it would be of great interest and service.

Lieutenant H. P. Norton, U.S.N., invited by the Chairman, remarked that all he could say was that they had done exactly what was here being recommended. All the changes and improvements which Mr. Morison had so ably set forth had taken place in the American Navy, and at present they had nothing to ask for in that line. They had gone so far as to combine the executive and engineering branches into one, and in their Navy an officer's pay depended upon his length of service, and not upon which branch of the service he belonged to. They all started with the same pay, and after a certain length of service the increment was the same. So the engineer-in-chief received the same pay as a rear-admiral if he had the same length of service. On courts martial, it had always been the regulation that the majority of the court should be composed of the same corps as the person to be tried, the president of the court depending upon the rank of the officers of the court, regardless of the corps they belonged to. They had made the change combining the engineers and the executive branch recently, and he could not say how it would work out, but they had great hopes that if properly administered, and in the same spirit in which the law was passed, that it would be all right. For several years a cadet, on entering the service, might not know whether he would belong to the engineering or the executive branch: the education for both was identical for the first three years. At the end of that time the assignment was made, and additional engineering studies

were given to the cadet for that branch, and the cadet for the executive branch was given additional technical studies to fit him for his duties, but both had the same foundation. At present the education and training of all cadets were the same, and all officers now entering the service, and all officers now in the service up to the grade of lieutenant were assigned either to the engineering or executive branch, as the department might see fit. They might do part of their course in one branch and then change to the other; and he had great hope that they had solved the difficulty. It seemed like old times to hear the speakers, for he had heard the same thing discussed twenty years ago in the United States.

Mr. R. HIRST thought they were all very much indebted to Mr. Morison for having brought a subject of such national importance before the Institution. They had all been very proud of their Navy, but it was startling to find that there were so many weak links in the chain. Engineering was the mainspring of a warship, and the development of machinery with its increased intricacies was so rapid that unless prompt measures were taken to remove the many and evident weaknesses which Mr. Morison had pointed out it would be impossible to obtain from our warships their maximum values in attack or defence. The general public did not realise the dangers, so that a very grave responsibility rested with those in authority, and if they also did not understand or appreciate what engineering meant to naval success, then a discussion of the subject by this and other institutions would be of great value in that it would voice the opinions of engineers as a body, whose interests in this matter were not personal but national. Mr. Morison rightly characterised as "monstrous" the unfairness of engineers being placed "in lieu of" chiefs without the extra pay and privileges due to that position. If they were competent to discharge the additional duties and undertake the additional responsibilities they should enjoy the rank, pay and privileges appertaining thereto. Another injustice which had escaped mention was that an engineer officer on passing out of Keyham College went to sea for one year as a "probationary" assistant engineer, at the end of which he was confirmed in the rank of assistant engineer. His seniority did not date from his entry into the service but one year afterwards, or when he became assistant engineer. When a midshipman was promoted to "acting" sub.-lieutenant, and his rank consequently confirmed as sub.-lieutenant, his commission dated back, so that he counted seniority from the date he was first made "acting." Thus a midshipman might, and frequently did, pass over the head of an assistant engineer by a year's

seniority. The effect was felt in many ways by the engineers. For example should there be a cabin vacant a newly promoted sub.-lieutenant might be by this process senior to an assistant engineer, and therefore claimed it, although the engineer might have had his stripe a year longer. The unfairness of this arrangement was obvious, but it was representative of the treatment to which engineer officers were subjected in H.M. Service and was one of the many causes of the intense dissatisfaction which existed, and which must react on the efficiency of the Navy. He was convinced that the only real solution of this question was that the engineering branch should be formed into a separate combatant corps with the executive power and the titles that always go with it. This would result in the engineers being regarded as a branch of the present executive line. All the bickering and jealousy which now existed between the two great branches would thus be obviated, and as the engineering branch grew in numbers and importance this jealousy might and would increase. Such a state of matters could not be to the advantage of the service. It was deplorable that these branches of the Navy should be abusing each other through the public Press, and continually pamphletizing Members of Parliament, but it was inevitable that this would go on if the engineer officers were not treated in the matters of position and pay, and also given the proper opportunities to carry out their duties, as were the executive officers of the Navy. The only way to satisfy both parties would be to get them very largely from the same classes and make their interests common. All engineer officers believed very generally that the Admiralty were trying to lessen the influence and undermine the importance of the professional engineer in the Navy, by the creation of an *amateur* engineering corps in the persons of the torpedo lieutenants, who, because they were connected with certain mechanical work and nursed by the engineer officer, deluded themselves, and many of their seniors, into the notion that they could in a large measure supplant the engineers. It would be a very bad day for the Navy and the country if this idea should ever be allowed to prevail.

Mr. W. G. Spence wished to add his assent to the general feeling of the meeting, namely, that the subject was of sufficient importance for action to be taken. He sincerely trusted that the outcome of that meeting would be some form of action. Some of the points brought forward by Mr. Morison he could not criticise from personal knowledge: but it had been a matter of common notoriety in engineering for years, that the number of engineers in the Royal Navy was

insufficient for active service and that there was not sufficient reserve available at short notice. Mr. Marshall in his remarks made a suggestion for quickly raising a reserve of artificers from among the fitters and chargemen constantly employed by engineering firms doing Admiralty work; but without wishing to dissent altogether from that he would submit that one of the very first essentials of naval war, and one that this country claimed to have great advantages in, was the ability to rapidly repair or replace machinery damaged in action. If at the very outset of the war they depleted their best firms of their specially trained staffs he was afraid they would seriously impair the force they had to look to for repairs. Above everything he believed the rapid repair and renewal of parts was essential, quite as much so as the satisfactory manning of the machinery at sea. In the event of a war round our coasts he should expect one of the first results to be the hobbling in of "lame ducks" at our ports. With modern high explosives and rapid fire guns the destruction of material must be great, and unless they were in a position to rapidly effect repairs the result would be serious. Such excellent firms as Mr. Marshall represented would be wanted badly enough when the time came without crippling them at the start. Next, as to drawing upon the mercantile marine for an immediate supply of ready made engineers. He knew from experience that to deal satisfactorily with warship's machinery the ordinary mercantile marine engineer would require some months training, otherwise he would probably make a mess of it. To think of such vessels being sent to sea with staffs that might be expected to make a mess of it, was not a satisfactory prospect. The mercantile marine engineer could not be expected to do the work without special training, and therefore he thought they should have a specially trained reserve staff. No one could expect a ship in peace to carry a full war complement, but there should be some means taken to have ready a large reserve of men specially trained for the Royal Navy. It was not beyond the art of man to form a large available reserve of engineers. As to the relative position of engineers in the Navy, no reasonable man could say it was satisfactory. The doctor's case was at one time hard. Originally he believed they were only ranked as gun-room officers. It was only after medical colleges advised their students that the encouragement given in the Navy was not such as to warrant their entering it that the number of medical applicants fell off, with the result that the demand became greater than the supply and the conditions were altered to suit. The same thing might be done in engineering. If the

powers that be did not make it attractive the supply should be curtailed, but better than this would be that some committee or body should bring advice, he did not say pressure, upon those in authority to make the service sufficiently attractive to bring forward the right class of men in sufficient numbers. He considered Mr. Morison was to be thanked for his clear, fearless statement of a real danger, and his effort to secure justice for the members of an honourable and important body of public servants.

Mr. G. W. Sivewright said it must be gratifying to Mr. Morison to see so large a number of members present and the manner in which his paper had been discussed. He thought one of the speakers had taken a reasonable view of the paper when he stated that it would not be an easy matter to get the engineers that would be required to man the ships efficiently in the case of a naval war. The Admiralty no doubt would expect to obtain a very large number of engineers, stokers, &c., from the mercantile marine and the factories on shore, but there was a possibility if we were conducting a naval war with a first-class power that we would probably also be engaged in extensive war-like operations on land, and from the example we have had of the number of transports required to convey soldiers and stores to South Africa he was afraid that the assistance expected from the mercantile marine could not be relied upon. In the case of a naval war where the fleets were of equal size extensive repairs would be required to the ships, armament, machinery, etc., and it would take all the manufacturing power of this country to repair these quickly so that the vessels could be put into action again. When they considered the large amount of foodstuffs required to be imported daily into this country the drain upon the staff of the mercantile marine would seriously affect the nation in other directions, and, from a financial point, it would not do to cripple the trading work of the country by depleting the mercantile marine of either engineers or sailors. He, for one, did not believe that it was the wish of the Government or Admiralty that either the ships should be undermanned or the men underpaid. The same trouble was being experienced all round just now in the Navy, and if anyone wished to fix any blame at all they should blame the country itself. If it could be pointed out that the nation was suffering from the undermanning of ships and the country was prepared to pay the extra amount of taxes it would cost to remedy this, he had not the slightest doubt that the Admiralty would only be too pleased to do this.

Seeing the very large number of mechanical appliances that were now being used not only in warfare, but in connection with the transport service, he was of opinion that if any nation took the precaution to give all their fighting force an engineering training and kept it up to date, they would have a far better chance of carrying a big war to a successful issue.

In further referring to Mr. Morison's paper there appeared to be other matters which could be put right that would not mean the expenditure of money, and he quite agreed with many of the speakers that this ought to be done immediately, and if the engineers were not paid higher wages they should at least have executive control over their own men and the same privileges as the deck officers.

He congratulated the Institution upon having such a paper put before the members for discussion, as it was quite right that the view of an important Institution like theirs should be brought to the notice of the public.

The discussion was adjourned and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS.

EIGHTH GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE SUNDERLAND LITERARY SOCIETY, SUNDERLAND, ON FRIDAY EVENING, APRIL 20TH, 1900.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT.

The SECRETARY read the minutes of the last General Meeting, held in Newcastle, on March 30th, which were approved by the members present, and signed by the Chairman.

The ballot for new members having been taken, the President appointed Mr. J. R. Fothergill and Mr. D. B. Morison to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Dippie, Joseph Robt., Ship Draughtsman, 130, Albert Road, Jarrow-on-Tyne.

Kennedy, William, Engineer, 14, Gladstone Street, Hartlepool.

Nevison, Thomas C., Engineer, c/o Messrs. Crosby, Magee, & Co., West Hartlepool.

Parker, James H., Engineer, Gladstone Street, Hartlepool.

Pollock, Walter, Marine Engineer and Naval Architect, Messrs. Jas. Pollock, Sons, & Co., 22, Billiter Street, London, E.C.

Wotherspoon, James Douglas, Engineer, 221, Linthorpe Road, Middlesbrough.

ASSOCIATE.

Moody, George Clark, Shipowner, H. King Street, Newcastle-upon-Tyne.

GRADUATE.

Joicey, Edward James, Engineer, 30 Bewick Road, Gateshead.

trans-Atlantic boats on composition, he wished it were true. Most of their poor composition manufacturers would be millionaires if it were so. If the sum of £200 to £250 were substituted it would be more in conformity with facts. Now, coming to the theory of prevention of fouling, the author divided this under three heads. First, the mechanical or exfoliating theory. He believed he could safely say that this theory only existed as a theory, but no successful method of preventing fouling was based on this theory. The chemical theory, or dissolving theory, should, he thought, be merged with the third theory of the biological or poisoning theory, because without dissolving, or more correctly speaking, without disintegration, the poisoning theory could not exist. In this connection he should mention, in order to avoid misapprehension, that by poisoning he meant poisoning by contact, and not poisoning through the stomach. The animals did not try to eat the paint and get poisoned in the process. In order to understand the principles which should be borne in mind in trying to avoid fouling, it was advisable to see in what form animal life attached itself, and in the consideration of this matter he would confine his remarks to the shells, or to give them their correct zoological name, Cirripedia. The young Cirripedia were ejected from the parental sack, according to Darwin, who was their first authority on this subject, as living larvæ. These larvæ underwent besides small changes, three important changes before they developed into the complete Cirripedia. Before assuming their third or final form they were pupæ. When leaving the pupæ, the young Cirripedia must either find a rock, a ship's bottom, or some other place to attach itself to or it must die. It was only in this stage that they had to deal with the animal, as in its other stages it did not require attachment. Now, the method of attachment was the following :—On the anterior end of the head a sort of soft cement was formed proceeding from a modified portion of the ovaria. This cement coming from the ovaria must, of course, be albuminous in character. According to his theory, the theory of poisoning, he coated the ship's bottom with a composition containing poisons which were acted upon by sea water, and in conjunction with the salt and oxygen contained in sea water formed a fresh poisonous salt or chloride, if they used mercury, a chloride of mercury, and if copper, an oxy chloride of copper ; and it was this new poison, created by the action of sea water, which was to prevent the attachment of animal life. Put any albuminous substance into chloride of mercury or chloride of copper and it would at once coagulate. When the young Cirripedia wanted to attach themselves they must come into the poisonous film with which the submerged

portion of the vessel painted with an anti-fouling composition was surrounded. The poison coagulated the albuminous cement, and the animal could not attach itself and died. This process was identical with that taking place on a vessel copper-sheathed or sheathed with metal. The sea water acted on the copper and produced oxy-chloride of copper, and this oxy-chloride solidified the cement through which the animal sought attachment, and the animal died. Copper might be exfoliating in the way it corroded or wore away. It was not, however, effective as a anti-fouler through exfoliation, but through the constant formation of oxy-chloride of copper by the action of sea water. No anti-fouling composition existed based on the theory of exfoliation, and it could not exist, because Cirripedia, once getting a hold on a ship's bottom, grow very rapidly, and in doing so penetrate with their base through the paint and find attachment to the metal surface, as could be seen any day when a vessel foul with shells was in dry dock being cleaned. If the theory of exfoliation were a tenable one, animal life would have to find attachment to the paint only, and not penetrate and get to the true surface of the metal, and the shell would fall off when killed in fresh water, which, however, was not the case. Zinc also acted in a similar manner to copper. When exposed to the action of sea water, it formed also an antiseptic salt destructive to low animal life. No doubt when people spoke about exfoliation they meant disintegration, or, as the author called it, the chemical or dissolving theory, and which, as he had already stated, was a necessary predecessor to his theory, or the poisoning theory. He believed Sir Humphry Davy, Mr. Van Meerten, Sir W. White, and others were not so much at variance with his theory as might at first appear. If they read the quotation by Sir Humphry Davy, and if he were to only alter a few words of it, it would be in complete harmony with his own views. The sentence reads :—

"The exfoliation of copper is the formation of a slightly soluble oxy-chloride of copper. Barnacles cannot therefore adhere firmly to the metallic copper, for between their scales and the metallic copper the oxy-chloride is continually formed by the presence of ordinary salt and oxygen contained in the sea water, and through its solubility it is washed away." Read it instead, "The disintegration (which may be exfoliating in its character) of copper is the consequence of the formation of a slightly soluble oxy-chloride of copper. Barnacles therefore cannot adhere (firmly) to the metallic copper, for between them (their scales) and the metallic copper the oxy-chloride is continually formed by the presence of ordinary salt and oxygen contained in sea water, and through its solubility it (the animal) is prevented from attaching itself (it is washed away)."

If they read or interpreted the quotation in this way, he agreed entirely with Sir Humphry Davy; and considering the state of the animal in

which it required to find attachment, and considering the mode in which attachment must take place, he left it to the meeting which was the more probable theory. But now, leaving theory and coming to practice, he maintained that every anti-fouling composition of the present day worthy of that name was based on his theory. They all, he could not say whether knowingly or not, were made so as to allow the poisons to be gradually disintegrated or dissolved by the sea water, and to form the oxy-chloride of copper, if copper was the poison relied upon, or the chloride of mercury if quicksilver was relied upon, or any other chloride combination between sea water and other metallic salts which might be employed. Then, again, the hundreds of experiments his Company had made proved that all metallic salts capable of entering into a chloride combination with the salts and oxygen in sea water were to the same extent, some more and some less, anti-fouling in their effect. Make a different chemical compound, which was quite as poisonous, or more so, out of the same metal, but which was not capable of forming into a chloride combination when acted upon by sea water, and they had no anti-fouling effect at all. Disintegration or dissolving was not effective in itself, which he could also prove by another set of experiments. He had tried different paints containing different metallic salts in different quantities, and had also tried paints without these metallic salts. In all cases was the action of the sea water on the paints identical, and the disintegration a uniform one. Those paints which contained the metallic salts up to certain percentages gave the best results, while those which contained only small percentages of metallic salts showed some anti-fouling properties, while those in which these salts were absent showed no resistance whatever to fouling. For obvious reasons he could not particularise these experiments.

The discussion was closed, and reply postponed.

ADJOURNED DISCUSSION ON MR. D. B. MORISON'S PAPER ON "THE BRITISH NAVAL ENGINEER."

Sir THOS. RICHARDSON, B.A., M.P., J.P., resumed the discussion on Mr. Morison's paper. He said that he was very glad to have an opportunity of expressing his views on the momentous question which formed the subject of Mr. Morison's able and valuable paper. He was of opinion that the paper was moderate in tone and free from exaggeration ; and although accurate and exhaustive in its treatment of a complex subject, it possessed the great merit of being perfectly intelligible to the educated lay public, no member of which could read and digest Mr. Morison's paper without becoming convinced that our naval engineers laboured under very serious disabilities which were detrimental to the efficiency of the service. It might be censoriously urged that, although a Member of Parliament and an engineer, he had not done anything to rectify the existing evils. Parliament and Parliamentary life, however, were not exactly what the public pictured them to be. Entry into Parliament was followed by many painful disillusions, and one's preconceived ideas on various features of representative government were forced to undergo considerable modification. He had not long enjoyed parliamentary honours before he realized that the engineers who found their way into the House were in so insignificant a minority, that they were practically powerless to influence government policy, even on matters of purely engineering import and interest, and he felt sure that his friend, Sir Theodore Doxford, would bear him out in this. Of course the engineer members enjoyed the right to address pointed questions to the occupants of the ministerial benches, and when a discussion arose they might find an opportunity to express their views. These privileges granted to the representatives of the people were, however, of a value which was more apparent than real, so far as the achievement of practical results was concerned. Ministers were trained experts in the art of replying to questions without answering the enquiries, and he had observed that they always expended a great deal of the available time on very trivial points, whilst the points of essential importance were very superficially dealt with. In assessing the practical value of the right to address the House, it should be remembered that the only effective political force was a numerical majority. Quite apart from the national importance of a subject, the

merits of a particular case, or the convincingness of an argument, the creation of a concensus of expressed opinion on any question was dependent upon a multiplicity of complex forces which could rarely be controlled or directed otherwise than by a recognised party leader. He believed that it was only by educating the public mind that those in authority could be induced to eliminate the serious elements of inefficiency which Mr. Morison had shown to exist in the Navy. They were told that the Admiralty could get plenty of engineers, but he doubted the accuracy of such statements. In time of peace, by overworking the engineers and taking numerous unwarrantable and highly dangerous risks, it might be made to appear that there was a sufficiency of engineers, but the question was how would things work out in time of war, when ships would have something more to do than to make slow voyages to and from foreign stations, or participate in manœuvres for a few days at a time? It might be possible that Mr. Morison's paper, placing the matter as it did, clearly before the public, did not meet with approval in all quarters; personal interest, business policy and other considerations were bound to influence the actions of many men in a matter of this kind, and many of those who did not actively oppose the cause of reform refrained from supporting it even though they were perfectly convinced as to the existence of the evils. The particular question with which they were now dealing was, however, of such national importance, that all personal considerations should be put aside, and the whole subject should be treated fearlessly, and in strict accordance with the ascertained facts. He thought it a very unfortunate thing for this country that the advancement and encouragement of the naval engineer should have been wilfully retarded by service jealousies, and by a spirit of conservatism, which had apparently failed to realise the fact that an entirely new position had been created by the marvellous growth of engineering in the Navy. It may be that at one time a mere engine driver was competent to take charge of the simple machinery on board Her Majesty's ships, but the conditions existing to-day demanded a very different class of men to successfully fulfil the onerous duties of an engineer officer. In fact the engineer officers of to-day were necessarily the intellectual and physical equals of the officers of the Executive Branch, whilst a knowledge of their profession was more difficult to acquire, and their duties were more onerous and dangerous to fulfil. In spite of these facts they were placed in a humiliating position of inferiority, which deprived them of the powers required to enable them to exercise effective control over their own

men. The well-known disabilities of naval engineer officers undoubtedly acted as a serious deterrent to enlistment into their ranks, and until the evils, so lucidly described in Mr. Morison's paper, were rectified, the best and most desirable classes of young men would decline to enter the engineering branch of the Navy, whilst those who were already in the service would continue to be discontented and disheartened, instead of being contented and enthusiastic. This was a most dangerous state of affairs, as it decreased, to an alarming extent, the efficiency of the engineering department, and should at all costs be altered. As an example of the manner in which these questions were dealt with in Parliament, he might state that during the present Session Mr. Macartney in his reply said that on enquiry among the naval engineers, it was found that they did not want executive rank. This was a most misleading statement; it was quite true that the engineers did not want executive rank *in the line of command*, but what they did want was executive power in their own department over their own men. It was not difficult, he thought, to show that many of the answers given in Parliament were incorrect, but it was not so easy to refute the replies, on the spur of the moment, and without reference to documents. In connection with engine-room artificers, he would now relate an incident which occurred at his own works. Two naval engineers visited the works about two years ago, and asked if they could provide them with six young intelligent journeymen to become artificers. Mr. Morison saw the engineers, and gave them his personal assistance by ordering notices to be posted up in the works. He waited some time, but there was no result; he then decided to interview some of the most likely young journeymen, and upon doing so, the reply he received was that they had no intention of volunteering, for the reason, as they put it, that "if Naval Engineers were so badly treated, what chance had the Artificers?" Some time after that Mr. Wawn, as they knew, was appointed to that district as recruiting officer for naval artificers, and he wrote to Mr. Morison, who passed the matter over to the works manager, thinking that, as he came into closer contact with the men, he might be better able to achieve some results. In this he was disappointed, however, for (as in the previous case) there were no applicants forthcoming. A few months ago he happened to be sitting in the office, when a young man sent in and asked if he could see Mr. Morison. He (Sir Thomas) enquired what he wanted, and it appeared that he was applying for a certificate of good character, as he was going to become, as he called it, an "arcifiter." He subsequently enquired

what this man's employment had been in the works, and discovered that he had been working as a striker in the blacksmiths' shop. He put it to them as engineers whether that man was ever likely to be of use as an artificer in Her Majesty's Navy? He understood that his experiences in this direction were only typical of those of many other employers, and he thought it would give the meeting some idea as to the difficulty which the authorities were experiencing in obtaining engine-room artificers for the Navy. He held that the inducement to men to join Her Majesty's Navy as either naval engineer officers or as artificers should be such that there would be eager competition for the appointments, instead of as at present, reluctance if not aversion. When they considered the enormous sums of money spent on their Navy, which he thought they would all agree with him was the finest in the world, surely it was of the greatest importance to have the best engineers which this great engineering country could provide, to take charge of the all important machinery on our ships of war. He firmly believed that unless sweeping reforms were carried out, a naval war must result in serious disasters, which would be rendered the more lamentable by the knowledge that they could, to a great extent have been avoided by the exercise of prudence and foresight. He agreed with Mr. Morison that it would be far better to increase the efficiency of our existing ships, rather than to continue to increase their mere numbers and paper values. The physical endurance of a man was limited, and if the staff of officers were such that early physical collapse of the chief engineer officers occurred, the result must be that the paper speeds of the ships could not be obtained, and there might be a parallel to the disaster which overtook some of the Spanish war ships so tellingly instanced by Admiral Melville. He was very glad to see that the matter was not to be allowed to drop so far as that institution was concerned; he was very pleased to note that certain resolutions were to be proposed, and that he was to have a position on the committee. He could only hope that other institutions would take the matter up and join with them in their advocacy of reform, for he believed that if the kindred institutions voiced their opinions fearlessly and in unmistakable language, the Admiralty would see the necessity for giving the whole question of the engineering personnel their very serious and prompt attention. They all sincerely hoped that the country would have the good fortune to see the requisite reforms carried into execution before becoming involved in a naval war. A naval war would immediately reveal our true weakness, but it would be then too late to profit by the knowledge thus gained.

Mr. J. R. FOTHERGILL, Vice-President, said he wished first to thank Mr. Morison for his very able and most important paper, and express his admiration for the courage and determination he had shown in ventilating a subject of such serious interest. He was deserving of the highest praise for the way in which he had made public such anomalies as existed in the engineering department of the Navy. Although Mr. Morison held an important position at one of the large engineering establishments in the country, he had no axe to grind, and deserved credit for the unbiassed way in which he had placed his views before the Institution. The paper was not merely a plea for consideration of the engineers, although that of course was a primary point, but the whole question was one of national importance. It was of national importance that they should see their battleships were not undermanned, and that as fighting machines in which, if mobility was to be an essential feature, the highest efficiency and complete staffing of the engine-room became an absolute necessity. It was very proper to bring this subject before the Institution as he thought there could be no doubt the expressed opinions of the members, many of whom were thoroughly recognised marine engineers, would influence public opinion and carry weight with the authorities. He must confess personally that when he first read Mr. Morison's paper, although he understood there was some dissatisfaction amongst naval engineers as to the anomalies that existed, yet he had no conception there existed a state of affairs so deplorable as that set forth in the paper. The country spent millions over ironclads, and no doubt all that was possible was done to perfect the machinery to the highest state of efficiency, and yet this being done, the engine-room staff was depleted, due to the fact that engineers could not be got to enter the Navy owing to their request for reasonable and proper recognition being persistently refused. What was a modern ship of war? A box of the most complicated and intricate machinery. How was it possible to keep such machinery in a high state of efficiency unless the engineering staff was highly efficient, and there was a full and complete complement? Mr. Morison in his paper, page 213, gave a very complete detailed description of the machinery of a modern warship, and on page 188, would be found the duties and responsibilities which the engineer was required to undertake. It must be patent to every man who had any knowledge of such responsibilities that it was only highly educated and thoroughly trained men who were capable of undertaking them, and that the duties required necessitated a very full and complete complement. It had been said that in case of an emergency patriotism would supply the deficiency.

No doubt men would be found to offer their services, but they would certainly be a very different class to the highly educated and trained engineer of the Navy, and it certainly would take some considerable time before they could be placed in responsibility. It was all very well to point out the numbers who had volunteered as soldiers for South Africa, but it was a totally different thing producing a naval engineer to making a soldier out of a volunteer. They might consider the question from another aspect, a commercial aspect. Although the man-of-war was a fighting machine yet as to its machinery efficiency it was interesting to compare the conditions with those commercially run steamers of the mercantile marine in the Royal Mail Service. Compare the engine-room staffing of the Cunard Liner "Lucania" with that of H.M.S. "Terrible," (pages 189 and 190 of the paper). Owners of mercantile steamers did not carry, out of philanthropy or for any other reason, one man more than experience had proved commercially necessary to do the work efficiently, and although in the "Lucania" there were no gun-mountings, torpedoes with their carriages, submerged tubes and gear and air compressing machinery, hydraulic pumping and other engines for loading and working the guns, for supplying ammunition, and for turning turrets, barbettes, platforms, &c., &c., yet the engineering staff in the "Lucania" considerably exceeded that of the "Terrible." Although artificers were carried in warships yet they certainly could not be considered on an equality with the assistant engineers in the mail service, nor yet did they come within the scope of "The Duties and Responsibilities of the Naval Engineer," as given in the Queen's regulations, whereas the majority of the engineers in the "Lucania" held Board of Trade Certificates. The war in South Africa had offered a great opportunity to test the absolute efficiency particularly of the cruiser class. If some of these vessels had been sent with all speed with troops to the Cape, the Admiralty would have obtained a most beneficial practical experience, and one could not help but feel the question of the engine-room staff would have been solved, besides proving how far such vessels were qualified to act in case of emergency, such actual experience would have been of infinite greater advantage than any committee appointed by the Admiralty, particularly such a committee as referred to by Sir Fortescue Flannery in his letter. Why could they not follow the very satisfactory and beneficial results which America had promulgated, instead of secret committees, by which the public naturally inferred there was a something which dare not be disclosed. He was at a loss to understand who was really to blame, and wherein was the objection and difficulty which persistently kept the engineer in the back-

ground so detrimental to the best interest of the Navy. It seemed incredible that admirals and captains who were highly educated and able men could feel happy and comfortable in their ships knowing as they must know that the mobility and efficiency of the ships under their command, so absolutely dependent on their machinery, were altogether unreliable, due to an undermanned and overworked engine-room staff, or else they must be incredibly ignorant of the state of affairs. Since the paper was written he had taken the opportunity to communicate with friends who did know what was going on and he would read to the meeting the following communications which he had received and which he vouched for as absolutely true :—

1.—More than £12,000 is allowed annually as Good Service and Naval Pensions to officers of the Executive and Medical branches R.N., and of the Royal Marines. No engineer officers are in receipt of Good Service or Naval Pensions.

2.—During the Naval Manœuvres of last year, in H.M.S. "Argonaut" 1st class cruiser, it was found necessary in order that the ship should keep to sea at the speed required of her, to transfer no fewer than 144 men to the chief engineer's department from other parts of the ship. Would, or could this be done in time of war ?*

3.—On the Contractors' trials of H.M.S. "Goliath," the number of naval stokers appropriated to the ship was 261, her full complement of stokers when in commission is 108.*

4.—Over 100 (106 per official Navy List of April, 1900)

* EDITOR'S NOTE.—As some members after the meeting expressed the opinion that the numbers of men referred to particularly in paragraphs 2 and 3 were incredibly large, Mr. Fothergill has since made additional enquiries, with the following results :—

Paragraph 2. The number 144 is perfectly correct (48 in each watch). These men were necessary for trimming purposes.

Paragraph 3. The ordinary sea complement of H.M.S. "Goliath" is :—

12	Engine-room Artificers.
6	Chief Stokers.
16	Leading Stokers.
108	Stokers and Trimmers.
142	Total.

Whereas the number of men appropriated on the contractor's trials were as follows :—

18	Engine-room Artificers.
16	Chief Stokers.
25	Leading Stokers.
202	Stokers and Trimmers.
261	Total.

An increase of 46 per cent. required when working at full power.

engineer officers of the rank of engineer are filling posts "in lieu of a chief engineer" (in destroyers chiefly), and of these more than half are of rank senior to their respective commanding officers.

5.—Article 967 Queen's Regulations and Admiralty Instructions states :—"The engineer officer is to have charge of and be responsible for the maintenance in a state of working order, and, so far as may be, of readiness for immediate use, of Whitehead Torpedoes and Submerged Tubes and Gear."

Although the engineer officer is responsible for the delicate and intricate mechanism of all torpedoes, execute all repairs to them, charges them and adjusts them before running, also is in charge of the only intricate part of the Electric Lighting arrangements (the Engines and Dynamos), he receives no extra allowance for such duties; the so-called Torpedo lieutenant receives in many cases as much as 3s. 6d. per diem. for his responsibilities with regard to the very small remaining work required to be done.

6.—The following case is cited in an article appearing in the current number of 19th Century, by Mr. H. W. Wilson :—"Are we misled about the Navy?" The facts are familiar. The "Proserpine" a vessel (cruiser) of 5,000 N.D., and 7,000 forced draught, horse-power, was sent out to the West Indies with two engineer officers and six engine-room artificers, late in 1898. As a logical consequence she broke down, and the junior of her engineers and an artificer had to be invalided home from worry and exhaustion. "One engineer and one artificer," continues the article, "may matter little in peace, but what if war comes?"

7.—When an engineer officer is specially promoted for meritorious services, he is promoted to the detriment of the officers who precede him on the list from which he is advanced, these officers' promotion being thereby delayed. To remedy this evil the promoted officer should be *additional* on the list to which he is advanced until such time as he would, in the ordinary course of events, have been promoted.

8.—Queen's Regulations (Articles 1160, 1161) allow of medical officers communicating with their head of department direct, the captain being allowed to merely *comment* on their letters. The confidential orders of at least one port (Portsmouth) (January /92, signed by the Earl of Clanwilliam, then commander-in-chief), lay down the principle that the captain is himself to write all letters dealing with technical matters, and is not to forward them in the

form of a letter from his engineer officer to himself with his own comments appended. While therefore the engineer officer may be robbed of any credit which the letter may call forth, he is necessarily saddled, on the other hand, with any blame which may be attached to it.

A case occurred in the Mediterranean (in H.M.S. "Banshee") where a letter written by the engineer officer reporting corrosion in his boilers was re-written by the lieutenant in command and put in such a form that a court of enquiry was ordered. The result of the enquiry was that the engineer officer had a letter of thanks from the Admiralty, but one cannot always be sure of things turning out so well.

9.—Nothing had proved more conclusively that a change of some magnitude was necessary, than an enquiry ordered by the Admiralty, and held in February last at the three Depôts.

For the last three years over two thousand stokers had deserted from the ports, and the evidence obtained from men of each rating namely, chief stokers, leading stokers, stokers, etc., clearly proved that with proper care and interest on the part of officers who are at present responsible for the comforts of the men, such a serious state of things might have been avoided.

This strongly points to the necessity of engineer officers having executive rank.

Time was too limited to comment on the communications which he had just read, but they showed a condition of things intolerable. In conclusion he was glad to see the resolutions which the President was to bring forward at the next meeting, and he hoped other institutions would seriously take up the discussion, and thus by united action bring pressure to bear on those in authority. The matter was no trivial matter. As he had before said it was a matter of national importance. Was the country for the sake of antiquated prejudice to allow the Navy to drift into a state of absolute inefficiency until our boasted supremacy was by the exigencies of war shown to be a delusion? Engineers must be had, and executive rank given, and the sooner this was done the better.

Mr. W. Mace said the paper read by Mr. Morison was one dealing with a subject to which he had evidently devoted much thought and preparation. He had exposed to the members of this Institution the

most unsatisfactory state of conditions under which the engineer officer of the Royal Navy labours. These officers were the back-bone of the British Navy, and why they should not have a standing equal to that of any other naval officials was a question demanding reform. He hoped Mr. Morison's paper would therefore have some beneficial effect. An engineer officer in the Royal Navy had not the power to punish a refractory stoker for insubordination, but must report him to his captain, who used his own discretion as to punishment, and therefore weakened the authority of the engineer in the eyes of the stoker, as was explained by Mr. Morison. Again, when a R.N. engineer was court martialled he was not represented on the Board at all, yet when a merchant service engineer was tried for neglect of duty the Board of Trade appointed engineer assessors. The pay of a naval engineer was inadequate in view of the stiff examinations he had to go through. Mr. W. Allan, the honorable member for Gateshead, had been ventilating this subject in the House, and great credit was due to him for the stand he had made. Let them support him, by Parliamentary vote and influence, and may he long be spared to continue his good work. Let this be the thin edge of the wedge, and let them unite and drive it in to its full extent, as by so doing they would no doubt not only remove the great weakness in the British Navy, but by pointing out the certain dangers ahead they would be fulfilling a duty to their country.

Mr. Alexander Dalrymple, of Liverpool, (by invitation) said that he had obtained the following interesting particulars of two examples illustrative of the relative positions and pay of engineers and doctors in the Navy. In each example there were two brothers who wished to become engineers, and in each example one brother failing in his examination as an engineer subsequently entered the service as a doctor.

Example No. I.

	Engineer.	Doctor.
Date of joining the Service	1st July 1884 ...	Feb. 1887.
Rate of pay on joining	6/- per day	11/6 per day.
Average pay of the two brothers from date of joining to 1/9/95 ..	£152	£231.

The engineer served eleven years before he attained the same rank and pay as that obtained by his brother, the doctor, when he first entered the service.

The elder brother is now a chief engineer on 14s. a day=£253 per year.

The younger brother is now a staff surgeon on £1 a day=£365 per year.

EXAMPLE No. II.

	Engineer.	Doctor.
Date of joining the Service	July, 1888	Feb., 1891.
Rate of pay on joining	6/- per day... ...	11/6 per day.
Average pay of the two brothers from date of joining to 1 9/'95 ..	£153	£228.

The engineer served eleven years before he attained the same rank and pay as that obtained by his brother, the doctor, when he first entered the service.

The elder brother is now an engineer on 11s. per day=£201 per year.

The younger brother is now a surgeon on 15s. 6d. per day=£283 per year.

The above cases are favourable, because owing to a change in the regulations these officers spent one year less in the rank of assistant engineer than is now the case, otherwise the years of service before reaching 11s. per day would have been 12 years, and $11\frac{2}{3}$ years respectively.

Under the concessions shadowed in Mr. Goschen's speech on the Naval Estimates the engineer would reach the doctor's rank six years earlier than shown in the statement, but the question of pay is altered to a very trifling extent.

Under present regulations an engineer takes 11 years to reach 11s. per day, and 14 years to reach 12s. a day ; making an average of 11s. 6d. per day, at which rate a doctor starts.

Under prospective regulations an engineer will take 9 years to reach 11s. a day, and 13 years to reach 12s. a day, or an average of 11 years for an average of 11s. 6d. a day.

The above years of service are only under the best conditions, viz.:—when the engineer takes a first-class certificate from college ; should he

take a second or third class certificate the length of service is increased six months and one year respectively.

Mr. Morison, although drawing attention to the dangers arising from the evident disabilities of the naval engineers had not set forth his views as to how the present anomalous position of the engineers could be positively and promptly rectified, but had included in Appendix C a moderate and comprehensive scheme drawn up by the engineers themselves. It had often been put forward by the enemies of the engineers and of reform, that the engineers' object was to command the ship. Such a wilful assertion of what is known to be absolutely untrue can best be answered by the following extract from a pamphlet entitled, *Naval Engineers and the Efficiency of the Navy* :—

It has for many years been an accepted principle in the British Navy, originally arrived at after careful investigation, that it is "undoubtedly desirable that officers should be highly educated to perform the duties of naval engineers, and hold the rank of commissioned officers,"* that is to say, that the most satisfactory way of dealing with the engineering department is to have just sufficient highly-trained commissioned engineer officers for the purpose of effectually supervising the skilled labour of the working mechanics. This principle applies with tremendous force to the conditions prevailing with regard to the mighty steamships of our present, and future, war navies, and the engineer officers of the present day are absolutely satisfied that the desired end can only be attained by placing the younger officers in charge of, and making them responsible for, all the different phases of naval engineering, including the actual keeping of watch in the engine-room.

A reference to the extract from the Queen's Regulations for the Royal Navy will show that practically the whole of the machinery of our ships-of-war—"museums of mechanical engineering" and "fiendish complications," Mr. Goschen has recently called them—from the main engines and boilers, now ranging from 30,000 horse-power in cruisers and 10,000 horse-power in torpedo-boat destroyers to the delicate machinery of the locomotive torpedo, is now, as it could only possibly be, in the hands of the thoroughly trained professional engineer; who, it will be seen, is there held solely responsible for its "maintenance in a state of efficient working order and readiness for immediate use." Any attempt to place this heterogeneous and intricate machinery in the hands of others, with only a superficial and imperfect training, must inevitably end in disaster, and if admirals and captains desire to sleep in comfort and security they will not permit of any tampering with the present arrangements in this respect. The executive officer in the British Navy possesses but the merest smattering of engineering knowledge, and this, too, almost entirely of a rudimentary and book-work nature. The instruction in these matters by an engineer officer of the same ship being invariably regarded by the young executives as an insufferable nuisance. An endeavour is indeed made, at the Naval College, Greenwich, to further instruct them in these subjects, but as they are entirely without subsequent practice, little is gained thereby. The electrical motors recently introduced into the Navy, in connection with work of minor importance, have been placed in

* Quoted from the Report of Admiral Cooper Key's Committee in 1897.

the charge of executive officers, but it must remain matter for grave doubt whether these officers, unskilled as they are in the use of machines, will be thoroughly able to deal with them. It appears to be only too apparent that as these motors become worn, or disabled, the assistance of the professional engineer will be needed to make good the necessary repairs. A very select few of the executive officers have, no doubt, developed clever, but crude, engineering ideas, and would possibly have made superlative engineers had they received the thorough professional training which is, in these days, an imperative necessity.*

It will be seen then that at the present time the Royal Navy is not prepared for a change of such a nature as has been made in the U.S. Navy, but the engineer officers of the former service, having given to this subject mature and thorough consideration, have evolved certain proposals for an improved organization of their branch (see Appendix C), which, from their extensive and collective experience, they are satisfied will improve the efficiency of the Navy, and be best suited to the needs of the present day. This course of action has, however, caused them to be subjected to persistent and venomous attacks, by those who must be destitute of any sense of shame. Had such proposals, put forward in the same spirit, but emanated from another branch of the Navy, they would undoubtedly have been received with warm approval in the highest service quarters.

The engineer officers of the Royal Navy have no desire to make attacks on their brother officers of the executive branch, neither have they any desire to supersede them in the performance of their duties on the bridge ; rather do they point to the loyal and hearty manner in which they have always worked to support those officers, with a view to placing our magnificent Navy in such a position that it shall be absolutely unapproachable in its efficiency and readiness for immediate use. They ask, however, that the organization of their branch shall be such as will enable them to satisfactorily deal with their ever-increasing responsibilities in connection with the developments of modern naval engineering. They wish to have complete control—*under the captain*—in the general administration of their own department, and to be freed from the arbitrary, and even dangerous, interference with their arduous duties by young and irresponsible officers of the executive branch. They have no desire to lose their identity with the great engineering profession to which it is an honour to belong, but they ask that, as commissioned officers of high standing, responsible for the decorum and discipline of large bodies of men, their rank and designation shall be such as to render it impossible for them to be placed in undignified and invidious positions with regard to the subordinate and warrant officers of other branches, and that theirs shall not be a mere quasi rank, which, originally adopted some 60 years ago

* "It is greatly to be regretted that the torpedo boats cannot show the same excellent records for their machinery, but it is sad fact that nearly every one has had some accidents, and the machinery of some at the close of the war was in a condition which can only be described as horrible, where boilers were burnt, cylinder covers broken, pistons and valves stuck, and everything in bad shape. This condition of affairs seems attributable to two causes, the absence of trained engineering supervision, and the use of the boats for duty to which they are not adapted.

Before the war the experiment was attempted of running the torpedo boats with only one trained engineer officer for the whole flotilla, leaving the care of the machinery of the individual boats to young line officers. . . . And a man without previous training does not become at once a skilled engineer by assuming charge of machinery."—(Report of the Chief of the Bureau of Steam Engineering, Washington, D.C., Oct. 1st, 1898.)

when naval engineering was in its infancy, tends to belittle them in the eyes of their men, and is not indicative of the real nature of their duties. Further, they ridicule the preposterous notion that the 25,000 officers and men of the engineering branch, already trained to some extent in military drill and the use of arms, should be ranked amongst the non-combatants of the Navy; and contend, that it is unnatural to expect officers to take a pride in a service, or a system, which sends them into civil life, to enjoy their well-earned repose after 30 or 40 years of such hardships as must be endured by engineers in H.M. Navy, without any mark of distinction other than that enjoyed by the ordinary civilian, although that service is absolutely dependent upon their work for its success as a fighting machine.

Sir W. Theodore Doxford, M.P., said as a member of the much abused House of Commons he came there to hear what the engineers had to say on this very important subject. He had been present when more than one deputation attended at the House of Commons to discuss this question with members privately, and he had also heard his friend Mr. Allan, the member for Gateshead, speak upon it several times, and he was quite convinced from what he had heard that the subject was one of the utmost importance to the Navy of this country. He agreed with his friend Sir Thomas Richardson that it was very difficult to do much on the floor of the House of Commons; but he thought the move which had been initiated here, if it was carried out on the lines suggested in the proposal which their President was going to bring forward would carry considerable weight with the Admiralty, especially if supported by the section of the House of Commons interested in, and having some knowledge of the subject. He was sure Mr. Goschen, Mr. Macartney, and others in authority would be prepared to give full weight to everything that might be placed before them, for they were anxious to do everything for the improvement of the Navy. If he could do anything in that direction he would be only too glad; but not being an engineer he was not prepared to enter into all the technical details of the subject, but he was satisfied they were making out a very good case.

The President gave notice that he would move, on behalf of the Council, at the closing Business Meeting to be held in Newcastle-upon-Tyne, on May 18th, the following resolutions:—

1.—That in view of the national importance of an investigation and discussion by Engineers of the subject matter of Mr. D. B. Morison's Paper, the Secretary be instructed to communicate with the various Marine Engineering Institutions throughout the Kingdom enclosing a copy of the paper and discussion, and suggest

that each should hold a Meeting for the discussion of the subject; that all such discussions should be incorporated in one volume, such volume to form part of the *Transactions* of each Institution.

2.—That a small Committee be formed by each Institution, the whole to be embodied in one General Committee which will draw up a report for submission to the Government as representing the opinions and recommendations of the Marine Engineers of the United Kingdom with reference to the Engineering personnel in H.M. Navy.

3.—That the following gentlemen be elected to form the Committee to represent this Institution:—Sir B. C. Browne, Sir Thomas Richardson, M.P., Mr. D. B. Morison, Mr. H. Withy, Mr. T. Westgarth, and Prof. R. L. Weighton.

The PRESIDENT remarked that what was wanted was, as the Royal Engineer is to the Army, so the Marine Engineer ought to be to the Navy. Besides talking they should also take practical means to go on working after their session was at an end.

The meeting then dissolved.

MR. W. C. BORROWMAN'S REPLY TO THE DISCUSSION ON HIS PAPER ON "THE TRAINING OF YOUNG ENGINEERS."

NEWSTEAD, WEST HARTLEPOOL,
MAY 21, 1900.

DEAR MR. DUCKITT,

I regretted very much my inability to be present at the meeting of the Institution on the 20th ult., and now beg to submit one or two remarks in reply to those gentlemen who were good enough to take part in the discussion of my paper.

The object of the paper was to put before the Institution some thoughts on the subject of technical education and its bearing on apprenticeship. For the most part it appeared to me that several members omitted to observe the real motive in the paper, and in their statements simply fastened upon the one part of it that seemed to them as of most interest.

Mr. Westgarth prefaces his remarks by stating that he has views rather contrary to those expressed in the paper, but as he proceeds his views and my own seem to coincide very exactly. No one would ever advocate the learning of a trade at a technical school, as this would be impossible, but, as he goes on to say, a man's value as a tradesman may be very much enhanced by his attending technical classes, and I am of opinion that "the why and the wherefore" are obtained not in the workshop so much as in the technical college, and that, to a certain extent at any rate, the elementary principles should come first and the practical application later. If the two can go on simultaneously so much the better.

Mr. Westgarth's remarks regarding the learning of foreign languages are very valuable, as it is becoming more and more evident that success in any industry will in the future depend upon the facility with which we can deal with foreigners in their own tongue.

I am very much obliged to Mr. Fothergill for the expression of his corroborative views of much contained in the paper. Mr. Fothergill has given the subject careful attention, and his contribution to the discussion is consequently of value. His desire to see employers give every encouragement to their apprentices to attend evening classes is becoming

every day nearer realization, because employers themselves see that, apart from the benefits it gives their apprentices, careful technical training conduces to the making of better workmen, because it is found that clever fingers usually accompany a well-informed mind. It may interest him to know that the writer makes it a rule not to engage any youth unless he undertakes to attend evening classes during his apprenticeship, his general conduct and the progress made at these classes determining afterwards whether he is eligible to sit at the competitive examination for entrance to the drawing office. When night shift or late work is in vogue those apprentices who are at the same time students are allowed to attend their classes, and so are prevented from missing any of the lectures.

Mr. Fothergill's reference to the training, or rather want of training, of sea-going engineers, is very true. The vision of the average sea-going engineer is often bounded by a very circumscribed horizon. After serving five years in a shop, frequently in only one department of a shop, he is sent to sea before he knows, to any useful extent, what engines and boilers really are. His life on board is not such as to encourage study, and after realizing his second and chief certificates what little study he has attempted stops. Firms are not so much troubled with the engineering part of their business as with the difficulty of procuring well-informed, thinking, qualified men to carry out their instructions on board with care and intelligence. A word in reference to this point might be said against those owners who give so little encouragement to the better class of engineers to go to sea. Perhaps the proposal of the Board of Trade to raise the standard of examination will tend to a bettering all round in this respect.

Mr. Craggs was surely not serious when he spoke as if it had been claimed that engineers were mechanics only. There was nothing in the paper which suggested anything that could not, with equal aptness, be applied to shipbuilders. Mr. Craggs must know that, in the *genus* engineer, the shipbuilder, the electrician, the mechanic are all included. The fundamental principles of these professions are the same always. The work of each is the "utilization of the vast sources of power in nature for the convenience of man." Hitherto the engineer has been looked upon as a mere technician, but this is only one of his many sides. His interests lie also in the problems of society, politics, finance. While building bridges and digging canals, or launching ships, he is stiffening up economic legislation, checking selfish political plans, pushing on industry, and developing civilization generally.

Mr. Craggs' concluding remarks struck a very high note, pregnant with truth. In the face of the rapid development of industry in other countries—a development which has its roots in the systematic training of their young—we must early recognize the necessity for carefully safeguarding and teaching our young tradesmen.

Mr. Robert Thompson's reference to the Board School boy and the envelope reminds the writer of a B.Sc. who was once asked to calculate the quantity of rivets that would be required to fix a structure together. His calculation indicated that about three times the weight of the whole structure would be wanted, and he was deeply hurt when he was asked to try again. What is wanted, along with other training, is the development of the judicial faculty—the power of discerning, without elaborate investigation, the true proportions of a thing. A youth may be highly trained in one direction only, and so be absolutely ignorant of the A B C of his business. It is right to encourage the natural bent of a lad's mind, if that be in a proper direction. There will thus be ensured a greater chance of success, there will be more heartiness in the lad's endeavours, for nothing helps towards success like a healthy enthusiasm.

Mr. Henry Gibson seemed to see a difficulty in specializing education, but if he remembers that this specialization is not advocated until the young tradesman is educated up to it, his difficulty should vanish. Education in its elementary stages should be common to all classes and professions—engineers, shipbuilders, medical men, divines—all should go shoulder to shoulder up to a certain point; then the divergence should occur and special study be introduced.

Mr. M. C. James's experience in some respects coincides very exactly with that of the author, but Mr. James, if he teaches still and is observant, will have noticed that the systems in vogue and successful several years ago are not sufficient now. As pointed out in the paper, and as recognised in every industrial country in the world, there is no such thing as a proper apprenticeship nowadays, and there is no doubt that those successful men Mr. James refers to, had they been guided in their endeavours towards the higher walks of their business when young, would have reached them sooner and with less difficulty. It is too true that the present system of technical education works only "fairly satisfactorily," and this "fair" degree of success is very much due to the gospel that avers that "an ounce of fact is worth a ton of theory." Such mis-statement of facts does great harm in young minds, not only by setting up two opposing schools of thought, but by actually retarding substantial

progress in research and discovery. It is not to be supposed that we think the less of the old masters of engineering, who have done so much for the profession without any theoretical knowledge whatever, but they would be, and are, the first to acknowledge that this old way will not do now; and they show this by coming forward in their own practical way, and giving liberally and cheerfully tangible sympathy by contributing large sums of money for the equipment and support of technical colleges. The leaders of these opposing parties have very crude and absurd views of theory and practice, and frequently indulge in somewhat grotesque statements. Without theoretical reasoning little or no advance would be possible from the ordinary ruts of practice, and nothing of a novel nature could be undertaken without first of all having recourse to expensive experiment. If, however, we can get the results of practice to agree with theory, the former is largely dependent on the latter. Where the danger of theorising lies is in the fact that some theorists, whose reasoning powers are of a mathematical turn only, deduce from assumed hypotheses certain theoretical results that cannot be proved to be true. The mathematical reasoning may be absolutely correct, but its application, as well as the assumption on which that reasoning is based, may be entirely wrong. Theory is surely not to be blamed for this, and so it is held in the paper that that young engineer who approaches his work (theoretical or practical) through a school where he is introduced to both will be the better able to say what may and what may not be of consequence to him afterwards.

Let us hope that Mr. James's idea of trade unions taking to do with the education of young engineers may not take practical shape in this world. They have already, in exercising their restrictive principles, brought to a dead level good, bad, and indifferent workmanship. If they take to do with technical education the ambitious and industrious apprentice will have to ask their permission to attend a restricted course of technical instruction, and all his ambitious initiative will be crushed out of him. It is to be hoped that our young artisans may see some day that their and the nation's interests demand absolute freedom, and that if this is not maintained their future will be dull indeed, let their measure of technical education be what it may.

We must all feel indebted to the President for the wise counsel contained in his remarks on the subject of engineering training. As one who has long taken a lively interest in apprentices, and who has given much thought and done much for young engineers, his words are of great value. It is true there is more in an apprenticeship than the mere

learning to file straight. There is the disciplining, enriching and strengthening of character, and the preparation of the youth's relationship to his fellow-men in his ultimate place in the world.

Mr. Muir's experience with apprentices is unfortunately a too common one. Out of a large number of apprentices attending classes the number of those who make any great headway, or who really study with a view to mastering the business, is not encouraging, and it is here that the fallacy of estimating our progress in technical education by the number attending classes is brought out. Perhaps if some such arrangement, as indicated by Mr. Thearle as prevailing at the Royal Dockyard, were to be introduced greater progress would ensue.

Mr. Dalrymple and Mr. Muir both agree with much put forward in the paper, and this support is very acceptable.

We are especially indebted to Professor Jamieson for his contribution to the discussion. He speaks with authority and with the experience of years to go upon, and in his usual thorough manner gives much sound advice to all. Professor Jamieson does not speak as a teacher only, however, but also as a practical engineer—as one who has not only studied and knows intimately all the systems of technical education in the world, and who thereby is able to glean what is best from all, but also as one who has been intimately associated with practical work, and so being able to direct and carry such on. His every-day intimacy with young engineers in the class room and in the workshop, as well as in the carrying on of much consultative practical work, gives Professor Jamieson's remarks on the training of young engineers exceptional value.

Mr. Fulton's contribution is very refreshing, and has quite a tone of Imperialism in it. It is quite true that instruction merely has hitherto been the order of the day, but this is so cheap now that to be instructed only is not nearly sufficient. Let us by all means have instruction, but let us also have a little education—not the pouring in of facts, but a healthy drawing out of ideas.

We are much indebted to Principal Woodhead for the contribution to the discussion he has sent in support of much covered by the paper. Districts with such gentlemen at the helm of educational affairs may rest assured that their youths are being guided in all that is best both for themselves and their industries.

Yours faithfully,

WILLIAM C. BORROWMAN.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

SIXTEENTH SESSION, 1899-1900.

PROCEEDINGS

CLOSING BUSINESS MEETING OF THE SESSION, HELD IN THE LECTURE HALL OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, MAY 18TH, 1900.

SIR BENJAMIN CHAPMAN BROWNE, D.C.L., J.P., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, held in Sunderland, on April 20th, 1900, which were approved by the members present, and signed by the President.

The ballot for new members having been taken, the President appointed Prof. R. L. Weighton and Mr. D. B. Morison to examine the voting papers, and the following gentlemen were declared elected :—

MEMBERS.

Ascroft, Fredrick W., E. Draughtsman, c/o Messrs. Harrison, Engine Works Ocean Works, Cross Lane, Manchester.

Byers, Wm. Lumsden, Engineer, 29, Thornhill Terrace, Sunderland.

Carr, Wilson Story, Consulting Electrical Engineer, 14, Percy Gardens, Tynemouth.

Cooper, Burjorjee S.N., Engineer, Sea View, Mahim. Bombay, British India.

Hall, John. Engineer, 54, Westoe Parade, South Shields.

Hogarth, G. V., Shipbuilder, 32, Water Lane, Maryland Point, London, E.C.

Warburton, F. J., Consulting Engineer, 3, St. Nicholas' Buildings, Newcastle-upon-Tyne.

GRADUATES TO MEMBERS.

Dickie, John P., E. Draughtsman, 18, Brinkburn Terrace, South Shields.
Lishman, John J., Jun., Marine Engineer, 16, Lovaine Place, North Shields.

ASSOCIATES.

Henderson, John T., Contractor, 5, Logan Terrace, South Shields.
Holzapfel, Max, Contractor, Maritime Buildings, Quayside, Newcastle-on-Tyne.
Tully, Robert, Marine Superintendent, 9, The Lawe, South Shields.

Mr. W. H. ATHERTON being unable to be present, his reply to the discussion on his paper was taken as read.

The Discussion on Mr. D. B. MORISON's paper on "The British Naval Engineer" was resumed and closed.

Closing business of the Session.

MR. W. H. ATHERTON'S REPLY TO THE DISCUSSION ON HIS PAPER ON "THE FOULING OF SHIPS."

DEAR MR. DUCKITT,

I have first to thank those gentlemen who, by taking part in the discussion, have so materially added to the value of the paper and to our knowledge of the subject of fouling. Much of interest has also been said on the question of corrosion; but, as that subject was not touched upon in the paper, no further reference will be made to it.

My authority for the statement that copper sheathing has been applied to wooden ships for centuries is a paper by Mr. M. Holzapfel, read before the British Association in 1889, where it was stated that relics of the ancient Romans prove that they employed lead and copper sheathing on the immersed parts of their ships. Apart from this statement, however, I have long had the impression that the practice of sheathing ships was very old; though just now I am unable to find any authoritative statement as to when copper sheathing was first used. Certainly Mr. Thearle is wrong in supposing that the Admiralty owed the first suggestion for the use of copper sheathing to Sir Humphry Davy. It is true that Davy was probably the first to investigate the theory of its action, and without doubt the first to suggest the use of zinc or iron protectors, to prevent the rapid wasting away of copper sheathing on wooden ships. But that is a very different matter. In 1824 Davy read a paper before the Royal Society "On the Corrosion of Copper Sheathing by Sea-water, and on Methods of Preventing this Effect," which was published in the Philosophical Transactions for that year. In this paper the following introductory passage occurs:—"The rapid decay of the copper sheathing of His Majesty's ships of war, and the uncertainty of the time of its duration, have long attracted the attention of those persons most concerned in the naval interests of the country. Having had my inquiries directed to this important object by the Commissioners of the Navy Board, and a Committee of the Royal Society having been appointed to consider of it, I entered into an experimental investigation of the causes of the action of sea-water upon copper." Now it is evident that the rapid decay of copper sheathing could not have *long* attracted attention, unless it had been in use for a long time antecedent to 1824.

Davy soon afterwards read two other papers on the same subject before the Royal Society.

I am obliged to Mr. Thearle for pointing out the true composition of muntz metal. Most authorities give 3 parts of copper and 2 of zinc; but some give 2 of copper, 1 of zinc, and a little lead. One authoritative work gives 2 of copper and 3 of zinc. It would thus appear that the composition of the alloy is very variable.

From Mr. Hurndall's remarks it seems to be quite an error to suppose (as Fairbairn did) that a foul ship would be made clean simply by lying in fresh water for a short time. It further appears that a good anti-fouling composition will keep a ship clean for a few months even in the worst of waters, no matter how prevalent may be the germs of fouling matter. If this be so I am pleased to learn that compositions have advanced in efficacy so rapidly. Not many years ago it was stated, in the pages of *The Shipping World*, that vessels lying at Surabaya for a *week*, at almost any time of the year, would get foul with the best composition ever invented. Sir W. H. White, also, in his *Naval Architecture*, wrote :—"No cure for fouling has yet been devised; the best compositions in use are only palliatives." Yet we are now assured, on the authority of both Mr. Hurndall and Mr. Holzapfel, that the compositions of to-day are entirely satisfactory. It is rather a pity, though, that the shipowners' opinion has not also been freely expressed in the discussion, it being just possible that a composition manufacturer may not be wholly unbiassed.

The statement on page 168 that "£4,000 a year is expended by some trans-Atlantic boats in overcoming the resistance due to fouling" has apparently given Mr. Holzapfel quite a wrong impression. As I understand the sentence, the cost of the coal wasted in driving the ship against the extra skin resistance due to fouling is meant, and *not* the cost of the anti-fouling composition.

The additional zoological notes supplied by Mr. Holzapfel, on the authority of Charles Darwin, are most interesting, and have an important bearing on the theory of anti-fouling. It is a pleasure to find that at least one manufacturer of compositions has studied the scientific aspects of the subject. For a very full account of the Natural History of Barnacles, reference should be made to Darwin's important *Monograph of the Cirripedia*, published in two volumes by the Ray Society, which I have had the good fortune to meet with, since writing the paper.

It seems that Mr. Holzapfel now repudiates the *poisoning* theory of anti-fouling; or rather, he says that by the word poisoning he does not

mean what is usually meant by that term, but coagulation of the external albuminous cementing matter. The word "poison" literally means a potion or draught, being derived from the Latin *pōtio*, a drink. Hence poisoning is essentially an *internal* process. It certainly seems to have been the idea of those makers of compositions who have used arsenical and mercurial compounds that, in some way, juvenile barnacles absorbed these substances, and were thereby poisoned in much the same manner as any more highly organised animal would be, if such active poisons were admitted into the stomach.

So far as barnacles are concerned, the true explanation of the anti-fouling properties of copper sheathing would now appear to be the following :—The compound (copper oxy-chloride) formed by the chemical action of the sea-water on the sheathing slowly dissolves and exerts a chemical action on the albuminous cement by means of which the young barnacles seek to attach themselves, which has the effect of coagulating this substance and depriving it of its cementing properties. Hence the young barnacles are unable to attach themselves to the copper sheathing. This explanation, I believe, also applies to mussels, oysters, and other shell-fish, but how far it may be applicable to grass and seaweed is not clear. The term exfoliation is sadly abused. It is clearly misleading to say that copper sheathing acts by exfoliation, for exfoliation means "to come off in scales" and *not* "to slowly pass into solution," which is an essential feature of the actual process.

In the case of compositions, the first stage is the gradual loosening and setting free of the active anti-fouling substance from the inert varnish in which it lies embedded. The next step consists in the dissolving of the particles of that substance in sea-water, accompanied by a chemical change differing for each substance. The last stage is the process of coagulation or curdling of the albuminous coating forming the medium of attachment.

I much fear that Mr. H. van Meerten would object to the interpretation which Mr. Holzapfel has given to his words ; which words, by the way, are *not* those of Davy. It may be instructive to quote what Davy actually did say in the third of his Royal Society papers* on the subject under discussion :—

When copper has been applied to the bottom of a ship for a certain time a green coating or rust (consisting of oxide, submuriate and carbonate of copper, and carbonate of magnesia) forms upon it, to which weeds and shell-fish adhere. As

* See *Philosophical Transactions of the Royal Society*, 1825.

long as the whole surface of the copper changes or corrodes, no such adhesion can occur. But when this green rust has partially formed, the copper below is protected by it, and there is an unequal action produced; the electrical effect of the oxide, submuriate, and carbonate of copper formed being to produce a more rapid corrosion of the parts still exposed to sea-water; so that the sheets are often found perforated with holes in one part, and comparatively sound in other parts. There is nothing in the poisonous nature of the metal which prevents these adhesions. It is the *solution* by which they are prevented—the *wear of surface*. Weeds and shell-fish readily adhere to the poisonous salts of lead which form upon the *lead*, protecting the fore part of the keel, and also to the copper, in any chemical combination in which it is insoluble.

Finally, with reference to the comparative merits of copper sheathing and anti-fouling paints, I have come to the conclusion that the latter have now so far advanced in effectiveness, and dry docks have so multiplied, that it is no longer advisable to incur the expense of sheathing steel ships—not even warships, save in exceptionable cases—and that the practice of sheathing such ships will gradually become obsolete. In saying this I assume that the statements made by Mr. Holzapfel and Mr. Hurndall in regard to the efficiency of modern compositions are substantially correct.

Yours faithfully,
W. H. ATHERTON.

The PRESIDENT proposed a vote of thanks to the writer for his paper on this very important subject.

This was cordially given.

DISCUSSION ON MR. D. B. MORISON'S PAPER ON "THE BRITISH NAVAL ENGINEER."

The discussion was resumed on Mr. D. B. Morison's paper on "The British Naval Engineer." The following communications were taken as read :—

TYNEMOUTH, *May* 17*th*, 1900.

DEAR MR. DUCKITT,

With regard to Mr. Morison's valuable paper, in referring to it, I do so with an apology, but it is only an expression of regret of the difficulty of putting forward new facts or arguments to enforce what has been so ably stated by Mr. Morison, and confirmed by others. The expressions of opinion at our last meeting were unanimous that it was our duty to take this matter up and press it upon the attention of not only this Institution but all others of a kindred nature, and in such a way as to convince the powers that be of the necessity for an immediate change. The efficiency of our Navy, and even the safety of our country, demands some action being taken. This is no petty personal matter. We do not seek to take anything from any other branch of the service, but we ask that our branch should be raised, so to speak, to a position consistent with its importance, and with the duties that will undoubtedly be expected from it on the day of battle. As engineers and men who will do what is expected, we have every faith in them, but there are too few of them. Just glance at the actual facts brought forward by Mr. Morison and confirmed by others. Fancy the comparison between the number of engineers carried in our merchant liners and those carried in some of the battle ships. The question is past answering. We can only wonder how this state of affairs has existed so long. It is no secret that there is a scarcity of engineers in the Navy, and can it be wondered at ? What is there to attract youths or men of the required character and education ? Is there any attraction in a position that cannot be defined ? He is responsible for the mistakes of his subordinates, and yet the control or authority over them may be in other hands, and evidently subordinates in another branch of the Service. Is the pay an inducement by comparison with other branches of the Service ? It is certainly not. Are the duties light, or is the position of naval engineer a sort of sinecure ? A glance at the complicated machinery of a warship, large or small, is an answer in itself, without reference to the

official list mentioned in the paper. It really seems as if only a certain number of engineers could be got, and that this number must be divided out amongst a certain number of vessels quite irrespective of the number that these vessels ought to carry. It has been stated that more could be got in the event of war or mobilization. It will be too late then. This is perfectly obvious from the fact that we have not sufficient for our present requirements. Much has been stated about making use of the engineers of our merchant service, and I am of opinion that this could be done to a certain extent, but in the same way that we have reserves for other branches of the service. I do not think that it would in any way cripple the merchant service if some engineers were called upon for service in the Navy. They would, of course, require a certain amount of training, but I do not see any difficulty in this, and when we know that in many of our large liners there are upwards of a dozen well qualified engineers, in addition to a large number of junior engineers, then it is evident that a number of these could be taken away without crippling such a steamer. I consider this point worthy of very close and careful consideration. I regret my absence prevents my going into details, but I feel sure from what has been said by so many speakers who are well qualified to express an opinion, that the matter will receive that urgent consideration which it demands, and Mr. Morison is deserving, not only of the thanks of this Institution, but of the whole country, for having brought this matter forward in so able a manner. Our Navy is undoubtedly the finest in the world, and that it should be in the least crippled by a want in this particular branch is very much to be regretted, and it is sincerely to be hoped that this defect will be remedied before it is too late.

Yours faithfully,

SUMMERS HUNTER.

NEWCASTLE-UPON-TYNE,

DEAR MR. DUCKITT, *May 17th*, 1900.

I have perused with pleasure Mr. Morison's able paper on a subject which is not confined altogether to a question of the status of the naval engineer, but develops into a national question, touching as it does the efficient manning of our Navy. Unable to be present at the previous meetings, therefore not in touch with the points brought forward in the various discussions, I hope that in the few remarks I have to make that I am not footing over trodden ground. The undermanning of our Navy

in whatever department is a matter that should appeal strongly to the nation at large, and Mr. Morison has clearly demonstrated, by comparison with the Atlantic liners, that the engineering department is in this serious condition, not only as regards engineers but also artificers, stokers and coal trimmers. This condition of things is not fully understood by the public generally, who do not care to be troubled with bogies and scares until they do come; but this and kindred institutions grasp the position and understand the danger it involves, more particularly those members who go down to the sea in ships, and who can fully realize the responsibility of the engineer on board our modern ships of war, a floating mass of machinery. It is well known the Navy is not attractive to our well-educated youths of the present day having an engineering tendency, owing no doubt to their being deprived of executive rank; and this compels the Admiralty to introduce "emergency engineers," "temporary service engineers," and "direct entry engineers" (described by Mr. Morison on page 187) in order to make up an efficient staff in time of peace. This, as you well understand, brings together a class of men widely different in technical attainments, which tells against the probabilities of Keyham College supplying naval engineers, consequently lowering the standard of efficiency. In the event of war, when the engineering staff in our Navy would require to be considerably increased, the Admiralty would no doubt fall back upon the mercantile marine to supply the deficiency by drawing from the engineers who have joined the naval reserve, and from that class would undoubtedly obtain thoroughly competent men for attending to the propelling power. But what about the numerous different classes of machinery, such as gun mountings, hydraulic engines for guns, turning turrets, barbette, platforms, torpedoes, torpedo tubes, etc.? The naval reserve is not, in my opinion, popular with the engineers of the mercantile marine, there being no inducement to attract our young men in that direction; the Admiralty requirements for the reserve are briefly as follows:—Assistant engineer to be under 30 years of age, must hold a 2nd class certificate under the Merchant Shipping Act, 1894, and have served not less than one year as a certificated engineer. Engineer to be under 35 years of age, holding a 1st class certificate under the Act, 1894, having not less than 7 years' service at sea, including 1 year's service as chief of 200 N.H.P., or second with engines of 500 N.H.P. or having 2 years' service in charge of a watch with engines of 1000 N.H.P. Senior engineer to be under 45 years of age, holding a 1st class certificate under the Act, 1894, having had not less than 10 years' service at sea, including 3 years' as

chief engineer of 500 N.H.P. or 1 year's service as chief of engines of 1000 N.H.P. It will be gathered from the above that in case of emergency the Admiralty requires the pick of engineers in the mercantile marine; but what are the inducements held out? Only that when called upon to join they will receive pay according to their rating, which is no increase on their pay received in the merchant service, and will then wear the uniform. The Admiralty would, I am sure, make this branch of the reserve more efficient and attractive if a certain number of engineers who had been accepted for the reserve were called up each year to serve on board the ships of our Channel Fleet during the autumn manœuvres. This would give them a training in the habits of naval life and discipline; and, after having completed a stated service with the fleet, to receive a retaining fee for a fixed number of years, by this means retaining the services of an efficient trained emergency staff. The investing of naval engineers with executive rank may become an accomplished fact somewhere in the dim and distant future, for old customs and prerogatives die hard. The Navy I have heard described as a "close corporation," and the members of this "close corporation" are drawn from the ranks of those who hold all the reins of power and authority in the land, no power being able to reach them because there is nothing tangible to attack, and efforts are uselessly expended; yet the power remains to repress and annoy the engineer officers, and this will be exercised all the more persistently the stronger and more practically their claims are placed before the public; but let us hope that the cherished wish of our naval engineers will be granted them, as they are a class of men who deserve better recognition from their country.

Yours faithfully,

DAVID ANDREW.

SUNDERLAND,

DEAR MR. DUCKITT, *May* 21*st*, 1900.

May I be permitted to say a few words in reference to the most admirable paper read by Mr. Morison before this Institution. For nearly 30 years I have followed with interest the development of the engineering trade of this country, the progressive strides made to combine theory and practice, thereby getting an infinitely better result than was obtained in the old rule of thumb days. From engineering being one of the crafts of the older days, it has now come to be a science. In like manner has the engineer of old now been obliged to train himself not only in the way of using tools, but also to

acquire a scientific knowledge of mechanics in order to be up to date. We have now in this country several splendid colleges where mechanical sciences are taught and where young men spend part of their life in order to cope with the greater difficulties which may come in their way in future life, when they are called upon to bring their theoretical knowledge into practical use, whether in the capacity of naval, marine, or ordinary engineer.

Such men who have trained themselves theoretically for the profession of an engineer and further combined their theoretical knowledge with the practice of the craft, should in my opinion rank in the social life as professional men. Why should the professional advantages in social life not be bestowed upon that great class of men who, I maintain, are the backbone of this country, men who in time of peril will show the world that England's strength is her boundless resources in all pertaining to machinery, whether in the shape of battleships, transports, or artillery, which are all products of engineering science. So far as I understand Mr. Morison's paper, it is not only the undermanning of the Navy which is in question—it is the position and the pay. If the position is first secured the pay will follow in its train.

Yours faithfully,

LAURITZ M. BODIN.

The following communication from an eminent American engineer has been received:—

WASHINGTON, D. C.,

DEAR MR. MORISON, *May* 15, 1900.

I greatly enjoyed reading your paper prepared for the North-East Coast Institution, entitled "The British Naval Engineer," &c., and while I was admiring that my attention was called to a somewhat similar article in the *Fortnightly Review* for April, entitled "With but After," by Rollo Appleyard.

I found in this country that we were immensely helped in our fight by the assistance of outside engineers of high standing, like yourself, both because their words carry weight with the general public and because such men could bring powerful influence to bear on our Members of Congress. Of course our final effort was made easy by the compromise with our line, or executive officers, under which we all worked together. Previously we had always been compelled to fight the line officers in anything we wanted to do, and it usually resulted in neither of us getting anything we wanted. I do not know whether there is

anything that the executives of the British Navy would like and to secure which they would be willing to compromise with the engineers, but, of course, if such a thing were possible that would be a great help in the fight.

An idea which has often occurred to me, even before our engineers in civil life began to help us, was that the fight of the naval engineers for proper recognition was in reality not merely something for their personal benefit, and also for the greater efficiency of the service, but a fight for the proper recognition of the profession of engineering. Unfortunately engineers are all so busy that they have in the past not paid sufficient attention to having the public recognise the great importance of the engineering profession, so that, of course, they did not realise that the inferior position in which the representatives of the profession are placed on board ship was stamping a badge of inferiority and secondary importance, not merely on the unfortunate men who fill the positions, but on the whole profession. The action of our own engineers in civil life here, and such things as your splendid article, show that engineers all over the world are waking to the importance of having the proper standing of the profession accorded to it everywhere.

In this connection it may not be uninteresting to you to state that a gentleman now in civil life, but who was probably the most active worker for the passage of the Personnel Bill among the engineers, had occasion to state to a member of our House Naval Committee the fact that engineers in all navies are not content with a position of secondary importance, but will demand the complete recognition of their value and the assignment of proper rank and titles. The Congressman, in attempting to belittle the claims of the engineers, took up the German Navy, and, referring to their titles, which are professional only, said that they seemed to be satisfied. The naval engineer replied that this was simply because the Congressman had not come in contact with any German naval engineers, while the speaker had, and he knew that they were just as discontented with their status as were American naval engineers. I make this point for the reason that, if you do by agitation get the matter considered in Parliament, or by a Parliamentary committee, you will very likely have this same objection raised; but, from all I can hear, engineers in every navy realise that in this age when the engineer rules supreme it is simply an anachronism of the worst possible kind to have the men on whom the real efficiency of the modern fighting machine depends holding an inferior and secondary position.

Both you and Mr. Appleyard have struck the right note in calling

attention to the serious menace to efficiency of the great fighting machines which results from the discontent of engineers with their position, as shown by the difficulty in getting men to come into the service and the anxiety of the best of those who are in to get a decent opportunity for leaving. That naval engineers with sons who want to enter the Navy should have them go into the executive branch, rather than into engineering, is most conclusive proof that something is terribly wrong, and the further statement that the older men discourage friends of theirs who think of entering the engineering branch is a further proof of tremendous significance. Prior to the passage of the Personnel Bill we had exactly the same state of affairs in our Navy, and we were constantly losing our ablest men, who, in many cases, were willing to accept positions in civil life, which paid little if any more than they were receiving in the Navy, for the sake of escaping from such an unsatisfactory life.

Those who oppose reform will, of course, say that the discontent is simply that of a few very ambitious men who aspire to positions for which they are not fitted, or, as it used to be put in the squabbles in the American Navy, "the engineers desire to strut in borrowed plumage." That nothing could be further from the truth is shown by the fact that the Personnel Bill gave about 60 of the transferred engineers the option of qualifying for general deck duties so that they might become eligible for promotion to flag rank, yet of all this number not more than 10 have actually taken advantage of the opportunity; showing that the fight of the engineer was not to get command of the ship, as was often stated, but simply to get out of an anomalous position, and to have his rank and position in the naval service so defined that he could pursue his work with some heart.

In some respects your men seem to be worse off than ours ever were, both in pay and in the matter of courts martial. While our courts were packed, in that there was always a majority of executive officers, we at least always had a representation on the court when any of our people were tried, and this gave an opportunity, in spite of the star-chamber methods of courts martial, for them to call attention to any gross injustice and at least make a recommendation for clemency.

The indifference of the general public to the question of the position of naval engineers is probably largely due to their belief that every officer in a military organization is invested with full authority over the men under him, and that this authority is properly backed up by the captain of the ship. The fact to which you call attention, that the men

of the engineers' force do not have the same respect for the engineers' authority as for the deck officers, was very marked in our own service, because the men realised that the captain and the second in command would not, of necessity punish them on the recommendation of the engineer, but that the engineer was just as likely, when the case came up for consideration, to find himself in position of defendant as the man against whom he made the charge. So marked was this feeling that I have heard engineers in our own service tell how, even in such matters as shore liberty, the men of the engineers' force, if at all dissatisfied with restriction by the engineer, would in some cases not hesitate to tell him that the decision rested with the second in command and not with him.

Of course in all these discussions we ought to be willing to state (if it is the case, and it often was in our service) that in spite of the insufficiency of legal authority for the engineer's standing he was probably generally upheld by the commanding officer; but there is no more reason why the engineer's authority should be entirely on sufferance and capable of annulment by a cranky or ill-disposed captain than that the captain himself should hold his authority on such a tenure.

The former engineer of our Navy to whom I have already referred put the thing rather cleverly at the first meeting of the Personnel Board in 1897, when he stated the claims of the engineers to be four:—

First:—The right to command their own men. To the ordinary public this might seem absurd, because of the popular belief that this right already exists. It did not in the American Navy prior to the passage of the Personnel Bill, and there is probably little doubt that any good lawyer could have cleared a man for refusing to obey an order of the engineer officer by showing that the statutes expressly deprived him of the legal right to issue a command.

Second:—The right to command any man at proper times and under proper conditions. I trust you have never had a case like several that occurred in the American Navy where there was one flagrant instance where a captain and an admiral actually attempted to put a commissioned officer under the command of an enlisted man, and he a negro rated as "landsman." I am glad to say that when the matter was appealed to the Navy Department the captain and admiral were not sustained. In the American Army such a thing has not been possible for the last fifty years, as they have long had the law that any commissioned officer, by virtue of his commission, may command any enlisted man.

Third:—The possession of real rank instead of relative, in order that there might be proper authority to exercise military command.

Fourth :—Military title in addition to the professional one, to show the actual standing of the officer in the military body to which he belongs. I think you have called attention to the fact that naval engineers are too proud of their profession to want to be separated from it, and I know such was the case in the American Navy. With our men, however, the granting of all the demands they had ever made came in the shape of accepting the military title to the exclusion of the professional one, but as it was accompanied by the agreement that every officer would be an engineer in fact, even if not so styled, they felt that they were getting the substance of what all engineers wanted, and that it would have been foolish to fight for a retention of the name when that might have prevented the securing of the actual thing itself.

One thing that has struck me in both papers is the extreme modesty of the demands made for the naval engineers. You have not asked for absolute equality as regards promotion, pay, &c., with the executive, but have been content with a very modest claim for amelioration of existing conditions. This ought to appeal to Members of Parliament in considering the case, as showing how very reasonable the demands are. As regards pay, American naval engineers were, as far as possible, under the old regime, on an equality with the executive officers, although, of course, as they did not attain flag rank they never got the highest rate of pay; but after attaining the rank of chief engineer their pay was a matter of longevity, so that they were really about as well off as the executive officers.

I was very glad indeed to note in your paper the strong emphasis you lay upon the fact that in urging the granting of the claims of the engineers *it is mainly on the ground of making the efficiency of the service as high as possible.* The appeal to the sense of justice of the average legislator is, unfortunately, generally fruitless. The politician is by nature and training a man of compromises and a trimmer, and his habit of mind gradually becomes one of considering simply what is the most politic thing to do, rather than what is the just thing; consequently the appeal in behalf of the engineers on the ground of the vital necessity of their content to the highest efficiency is the right line to follow. It is a curious thing that this does not occur to the people charged with the administration of navies, when it is so very familiar to the managers of all great private enterprises. They realise so thoroughly the importance of keeping the best men that they are very careful to see that all such things as pay, position, &c., are made satisfactory.

One other thought occurs to me in this connection, which I do not

think you brought out, although, I am sure, it is perfectly familiar to you, namely, the answer to the statement that will probably be made that the reason it is difficult to get young men to go into the corps of naval engineers is because the work is hard and involves life among grease, dirt and heat. This statement is absolutely false, and instance after instance could be cited to prove that it is. I have known personally every one of the bright men who have left the American Engineer Corps in the last ten years, and I know that not a single one ever weighed for a moment the question of the ease of the life. All of them loved their work and were fond of engineering. What made them willing to leave the Navy, and indeed anxious to do so, was discontent with their surroundings. A further proof has been called to my attention recently in connection with some of the large manufacturing concerns which endeavour to train young men in the practical side of their work after leaving a technical school, and require them to go through a course of several years at an exceedingly small compensation, and where they personally perform every species of manual labour in all branches of the establishment. They have no difficulty whatever in getting all the young men they want, and indeed, are compelled rather to turn away a great many who apply. The work is certainly not attractive in itself, but the young men recognize that it is this intimate acquaintance with the practical side of the business which will give them the strength to aspire to high positions in the profession later on. I am convinced that exactly this same state of affairs would exist with respect to engineering in the Navy if the status of the officers were made satisfactory; indeed to a man who has any mechanical instinct, watch standing, while not always pleasant as regards temperature and matters of that sort, is nevertheless intensely interesting when one thinks of the great forces under his control. The conning of the ship is mere child's play in comparison with it, and has nothing like the attraction. In the engine-room all is life and animation, and the engineer feels that he is really doing something in maintaining efficiency and economy in the working of the great engines under his control. On deck in the modern steamer the work of the man on the bridge in time of peace has become little more than that of an onlooker.

In time of war the man on deck has, indeed, the excitement of the combat and the thrill of danger to make his work attractive, but the man below has every bit as much, if not more, danger, and his work then requires the highest exercise of every faculty of which he is possessed. He knows that everything is being worked to its utmost capacity, and

that the successful working of each part of the organism is absolutely vital to the success of the ship as a whole, but he also knows that an accident to any one of the thousand little minor parts will disable the whole huge machine. In spite of all this he must not allow himself to get excited, but must keep thoroughly cool and be ready if anything does go wrong to make it right in a moment. I cannot believe that there is anything in this life which would be unattractive to any man of Anglo-Saxon blood ; on the contrary, it seems to me unusually attractive. That men who do this work should be discontented is only because they know that in spite of the vital importance of their work they do not get proper recognition, and to a man of the spirit which is absolutely neccessary to success as a naval engineer this constant ignoring of his merits, and failure to give him his just reward, are bound to make him anxious to get into some other line of business where merit is properly appreciated and where he will not see the credit, which is rightly his, given to someone else.

We have a notable instance in the American Navy in the case of the "Oregon." The remarkable voyage of thirteen thousand miles, leaving the ship ready to go into action at once, backed up by the fact that she was the prime factor in the fight at Santiago, was all due to her Chief Engineer (now Commander) Milligan. Milligan was not considered one of the specially shining lights of the Engineer Corps, but rather a thoroughly reliable man who would always give a good account of himself. The fact was, however, that he did look after everything, and was not content with simply making perfunctory reports to the commanding officer and then abiding by his decision. Every one realizes, of course, that the captain had nothing to do with the readiness of the ship to go into action after the long voyage, as this was an engineering matter entirely ; but it is not so generally known that Captain Clark wanted to get the "Oregon" into the condition of half-power, in which most of the other vessels were at the time Cervera's Fleet came out, and would have done so but for Milligan's urgent persuasion the other way, yet in spite of the fact that it was due to Milligan's efforts that the "Oregon" was able to do such magnificent work, probably not one person in a thousand of the general public even knows his name, while Captain Clark is given all the credit and is regarded as a remarkable man.

The head of one of our colleges in America, whose technical side is much the strongest, and who in consequence has been very much interested in engineering matters, once said, when asked by a naval engineer why it was difficult to get the executive officers to accord simple

justice to their brethren of the Engineer Corps, "History discloses very few cases in which the members of a privileged class have, of their own volition, agreed to an increase of their numbers by the accession of men from a class previously regarded as inferior;" in other words, the opposition to giving the naval engineer his due is largely a matter of class prejudice.

The successful outcome of the struggle in America for proper recognition of the naval engineer makes the fight by engineers in other navies that much easier, and it seems to me absolutely certain that in this age when engineering is the profession par excellence, the time cannot be far distant when the engineer will be accorded his proper standing.

Yours faithfully,

Mr. W. H. Dugdale said he was pleased at having an opportunity of expressing his appreciation of the important subject which Mr. Morison had so ably brought before this Institution, and desired to point out that some of the remarks which had been made might, he feared, lead to a misconception as to the real object and intention of the paper, although the author most clearly defined it in the title, and amplified it in his introduction, and especially on page 209. It was not merely a question of underpay, and lack of title and power, prompted by naval engineers to rectify their disabilities. It was a broad and abstract question of national importance taken up by this Institution at Mr. Morison's suggestion, because they felt that the engineering institutions of the country were the only bodies which could adequately discuss the question from an absolutely impartial point of view.

The question had been asked by him of the speakers why the Admiralty had not taken up this matter and put it right? And they were further asked is it a disinclination to spend more money? No, that is not the reason. He believed the reason was simply because neither the Admiralty nor yet those who had referred to the matter in the House of Commons fully realized the importance of the matter, nor the absolute necessity of a radical change in the present regime. Let them for a moment glance at the history of their Navy and they found that from its earliest days until early this century the development had been very slow indeed. For instance, as the galleys increased in size and two or three banks of rowers were required, a deck was added for the warriors and propulsion assisted by canvas, and thus about 2,000 years

ago they had the progenitor of their famous wooden walls: the progress from that period being gradual and tentative. The armament too made comparatively slow progress from the introduction of gunpowder until early in this century. And what of the naval officer? From the old warrior fighting with primitive ships and primitive weapons, his qualifications being simply indomitable will and physical endurance, he became an executive officer having larger responsibilities, more varied duties, and had to fight other navies with similar ships to his own. Still there was nothing in his ship he as a sailor could not undertake. His profession was surrounded by a halo of adventure and romance; was exceedingly popular, and there was no difficulty in getting sufficient men of the very best description. But the introduction of iron and steam made a distinct change, and the development during this century had been remarkable. The handling of a battleship at the commencement of the century was essentially an art, to-day it was distinctly a science. The earlier ships propelled by steam had simply a primitive set of engines and only required a man to drive them—an artisan— a man whom the naval officer, justly proud of his traditions, considered was socially and intellectually beneath him, and a sort of necessary evil. But with the advance of engineering science, they now find practically every known branch of engineering brought into requisition: steam, electrical, hydraulic, and pneumatic. As Mr. Morison said, the modern battleship was the very embodiment of engineering science, and the engineer produced the power and maintained for its every organ, its vitality and utility, and the naval officer had merely to navigate the ship and perform executive duties. What was the result? The engineer officer now must be a man with scientific attainments and be conversant with the principles involved in the various branches of engineering which were under his control, in short he must have a college training. The Admiralty recognised this and insisted upon it, but they did not realise that although they required men of the same social and higher intellectual attainments than the executive officer they offered absolutely no inducement which would attract men to this important branch of the service, but threw obstacles in the way. The college fees were higher, the pay lower, and the rank inferior to the executive branch, and they appeared to foster the unwarrantable class distinction which had existed so long and which was largely at the root of the evil. Mr. Morison had most clearly pointed out the various disabilities under which the naval engineer existed, and he could add nothing to what he had said. His (Mr. Dugdale's) object was to emphasize the gravity of the situation from a national point of view, and the fact that

it was from a sense of duty to our country that this Institution brought the question forward, and asked kindred institutions to join them in endeavouring to avert the danger which threatened the country. The naval engineers could not combine to point out the anomalous position they occupied, because their action would at once be misconstrued into an agitation to rectify personal and petty grievances; and although the success of their endeavours would naturally result in the removal of many of the naval engineers' grievances, and, he hoped, would give him the position and advantages to which he was so justly entitled, they would have accomplished a still greater object; they would have assisted in popularising the engineering branch of our premier service, and have contributed to the success and efficiency of the Navy, which was so essential to the progress, safety, and welfare of the country. Of course, one of the great difficulties they had to contend with was the innate conservatism of the Admiralty, who have always been chary of adopting necessary reforms (they opposed the removal of masts and yards from steam vessels, opposed armour clads, opposed breech-loading and quick-firing guns, and opposed increase of the fleet); and another difficulty was the natural opposition of the senior executive officers, who, of course, felt they were capable of performing all the duties involved by a modern battleship. It was, therefore, incumbent upon their and kindred Institutions to clearly point out to the country at large, and those who represented them in Parliament, the inadequacy of the present system and the absolute necessity for a radical change. Sir Benjamin Browne at their last meeting stated that as the Royal Engineers were to the Army, so ought the naval engineers be to the Navy. That he thought could not be better illustrated than by an incident which occurred during the recent siege of Ladysmith, by which they could see that if no naval engineer officers had accompanied the naval brigade the result of their operations might have been been very different. The 4·7 gun mountings which Capt. Scott was said to have designed naturally proved somewhat defective after a few rounds were fired, but luckily there were two naval engineer officers, and 2 E.R. artificers among the party, and the fleet engineer of the "Powerful" had thoughtfully sent a portable forge, anvil, angle bars, bolts, etc., so that when the bolts which secured the timber framework sheared, the engineer officers took the carriages to pieces, forged new bolts, and re-made the carriages, and as they could not do the work during the day, on account of the Boers firing on them, they had to erect them at night, and did it in two consecutive nights. Then to Engineer Sheen belonged the credit of making distillers out of a lot of

$\frac{3}{4}''$ copper piping, turning it into coils, and using a railway watering tank for its circulating water supply. He got his apparatus rigged up, and upon the third day after starting he was making at the rate of 15,000 gallons per day, and kept the troops going with fresh drinking water for a couple of months until the coal supply for his boiler ran out. This saved many deaths from enteric. He simply mentioned that to shew that even ashore the naval officer would have been severely handicapped if he had not been supported by naval engineers. Their necessity on board ship was of course obvious. The recent Admiralty concessions were unsatisfactory, as the real question had not been touched. Naval efficiency would never be gained until there was essentially but one class in the service, and they must have an engineering training; so that every officer of the two great branches must be to some extent interchangeable. The doctor and paymaster elements did not enter into the question, excepting that the paymaster could be abolished altogether and his place taken by a fighting officer "Engineer cum Executive." The American system approached efficiency more nearly than any other, and would succeed when the executive American N.O. loyally accepted the new situation and worked to qualify himself for engineer watch-keeping and other duties. The engineers in their Navy did a very large proportion of the important work of the ship now, and could easily take up executive duties, with a modification in their early training, the only thing needed in such a case would be to increase the number of engineer officers. Beyond the navigation and drill, they practically did all the work. What did a torpedo lieutenant do, except draw 4s. a day, the engineers kept the tubes efficient? Any one could press a button, but who kept the button in working order and so on? They were, therefore, perfectly within their rights in advocating executive control over their own men, all working officers should be executive and military. The present naval executive officer and the Admiralty Board as now constituted would never consent to confer military rank on the naval engineers nor to fuse the two branches, because they probably felt that, given equal chances, the scientifically trained engineer would be bound to come more and more to the front, and so in time would displace their own protegees from command and good billets. Now it was not the object of Mr. Morison's paper, nor yet of their Institution, to try to displace the naval officer, of whom they were so justly proud, by men of a different class, but they desired to bring about such changes in the present regime as would make the profession of the naval engineer to be as much sought after as

that of the present executive officer, especially as each year made the engineering branch of greater importance to the efficiency of the service. The engineers' demand for military titles and *real* rank was certainly not a matter of sentiment. But it was a very natural desire. The engineers were essentially a military branch already but were denied position and rank. *Relative* rank was not rank at all. Would the present executive officer care to drop his rank and the dignity his title conferred? Rank and dignity were the essentials of proper command of men by officers. Were the engineers not entitled to it then in order to properly administer their department? He regarded the demand for a separate engineer corps with military titles, and power to award punishment, and look after the discipline of their own men, as but a step towards the complete efficiency of the Navy, and that would not be secured until there was but one class in the service, *i.e.*, the "fighting workers," or the "working fighters" of the ship. In the old days the seamen made sail, repaired masts and yards, and fought the ship, so in the modern days the engineer should repair steam and other machinery, and fight the ship. It had been said that the navy engineer wished to be captain; that was not so; neither did they advocate it. The position had been very aptly compared to a tuning fork, the stem of which represented the captain, the two prongs, the two great branches of the service, and unless they synchronised or worked in unison the result would be imperfect. If all were trained as engineers to start with, there could be no jealousy, they would all be one set, one branch, this was the true solution of the problem. The remarks he had just made might be briefly summarised into two important demands. 1st. The engineer being such an important factor in maintaining the efficiency of the ship, and having such a large staff under his control, should of necessity have the necessary rank and authority to maintain discipline; and inasmuch as they had to perform executive duties, and were essentially fighting workers, their rank should be executive and military in the same manner as the engineering section of the army. 2nd. Seeing the paramount importance of the engineer officer in a modern fighting ship, the officers of the two branches should be to some extent interchangeable and that their early training should be the same. This being the system which had been with advantage adopted in the American Navy. The other great point which Mr. Morison had referred to but which had not been sufficiently emphasised in the discussion was the necessity for engineering representatives upon the Admiralty Board because there were so many questions of policy, of efficiency, and personnel, upon which engineers

only could speak with authority. And regarding the personnel, it was useless spending millions upon producing perfect fighting machines, unless they made the personnel which was to handle these machines equally perfect. If therefore they could in any way bring about a reform at Whitehall upon somewhat similar lines to those indicated, they should have done something to popularise a branch of the service, which, although most important, was also most unpopular, and had rendered a national service inasmuch as they would ensure the maintenance of the historic and traditional prestige of our British Navy.

Mr. JAS. STEWART did not think this subject was one which readily lent itself to discussion, and Mr. Morison had covered the ground so well in placing the facts before them that he thought the best thing they could do was to study those facts and do all they could to disseminate information on the point. The facts, he thought, spoke for themselves, and one could not read and study the paper without realizing their importance as well as the urgent need for reform. The hope of reform lay in the pressure of public opinion, hence the importance of making the facts as widely known as possible.

There was one thing he should like to mention, and that was the interest that had been taken in this subject by the Institute of Marine Engineers, as was shown by reference to their published *Transactions*. He had found it interesting at the present juncture to look through these, and noticed that in February, 1896, a paper had been read by Mr. Frank Cooper on the "Engineers of the Royal Naval Reserve," and in October, 1898, one by Mr. Jas. Adamson on "The Marine Engineer." These papers, and the discussions they gave rise to, were a valuable contribution to the subject brought forward by Mr. Morison, and that the Institute referred to was fully alive to the situation was shown by the repeated references to the subject in their discussions, and at their annual meetings, prominence being given specially to the urgent need for an improvement in the status of the engineers of the Royal Navy, and to the necessity of having a representative engineer on the Board of Admiralty.

He was very glad to find that the Council of this Institution was taking steps to act along with other institutions, and he thought he need have no hesitation in saying that they would have the hearty co-operation of the Institute of Marine Engineers, whose membership, he might mention, included such influential names as Sir E. J. Reed, Sir W. H. White, Sir A. J. Durston, Sir J. Fortescue Flannery, &c.; and the present

President, Col. Denny, M.P., had shown considerable interest in this same subject.

Mr. J. H. Heck said it was a pleasure to speak on this very interesting paper. He thought there could be very little question about the point that an increase in the number of the engineers meant an increase of the efficiency of the Navy. In the paper and remarks, reference had been made as to the difference in status between the engineers of the U.S. Navy and of the British Navy. If this was so, he thought it should not be so. There was something which seemed to deter young men of good education and ability from entering our Navy, he thought the most weighty remark made in the discussion was that made by the President (Sir B. C. Browne) that the naval engineer should be to the Navy as the Royal Engineer is to the Army, and Mr. Heck considered that if this paper was to be read or discussed by other societies the views of this Institution could not be better expressed than by the sound proportion put forward by the President.

Mr. Robt. Thompson (Past-President) remarked that he had been very much interested in the paper, and he could endorse all that had been said by Mr. Dugdale. He thought Mr. Morison had arranged his points very clearly, but to discuss the paper he should have preferred to have been in the Navy for a few years. He did feel this, however, that an engineer officer ought to have a better status in the Navy than he had at present. This paper and discussion appeared like the old fight they had in the mercantile marine between the engineering staff and the staff on deck. They had recently seen how very near they might be to disaster. He thought the personnel of the Navy should be put right; the staff not only increased in numbers, but the status defined, so that the engineers might have considerable power in their vessels. As was clearly shown by Mr. Morison, the engineers had not only charge of the motive power of the ship, but of the pneumatic and hydraulic arrangements for the guns, and also the electrical plant. The engineer was becoming the essence of the fighting power of the ship, and his full authority ought to be recognised in connection with the engine-room. The staff should be increased in numbers, and having scientific attainments should be given an opportunity for their ability to come to the front. By these means they would obtain a more efficient staff than at present. He thought the affirmation of the principles embodied in the resolution to be submitted to the meeting would eventually do some good. The discussion

of this paper so far away from headquarters would not, perhaps, have very much effect, but he did think a report drawn up by various committees would put the facts beyond dispute. He believed the account of the discussions in the House of Commons as given by Mr. Morison was absolutely correct. He looked forward with considerable interest to the report of the proposed Committee, and through the proper quarter it should have considerable influence; and if the grievances complained of were removed the paper would have attained its object.

Mr. Henry Withy (President-elect) said that he could not claim to speak on this paper with an intimate knowledge of the subject, but could only base his opinion on the particulars given in Mr. Morison's paper, and on the information derived from various other sources. It seemed perfectly clear that the great increase in the Navy had not been followed by a corresponding increase in the personnel, and particularly in the engineering branch, which from its importance should have received the first consideration. That was an indisputable fact, and in the interests of the nation should be put right with the least possible delay. Members of institutions such as this although they might not be intimately acquainted with the minute details governing service conditions of working, yet collectively they possessed a broad knowledge of the subject which enabled an accurate opinion to be formed which should be of considerable value to those responsible for the efficiency of our Navy. There was no doubt whatever that engineer officers should have executive control over their men, and it was quite a revelation to the lay public to find that such was not the case. If an industrial establishment were conducted on the same lines as the engineering branch of the Navy and no power given to the chiefs of departments over their own men, ultimate commercial ruin would be the inevitable result, as the maintenance of a high standard of efficiency would be impossible. That unfortunate system was also no doubt primarily responsible for the small number of engineers who desired to join the Navy; but if the various disabilities were removed there was no reason why the engineering branch of H.M. Navy should not be as attractive as the other branches, and draw equally good men. No better proof of the general position as regarded insufficiency of numbers was afforded than the fact that over one hundred officers of engineer rank were called upon to undertake the responsibilities of chief engineers; surely this was a most alarming state of affairs, and clearly showed that the number of chief engineers should be largely increased. To those who realised the present high standard of

mechanical engineering in the Navy it was apparent that the engineer officers should be highly trained men. The large numbers of intricate auxiliaries on a modern battleship, all of which required skilled attention and an intimate knowledge of their details, were distributed throughout the ship, and in action a large number were in positions which would be practically isolated, so if in times of peace the complements of skilled men were insufficient how were they going to manage in time of war. It was abundantly evident that it would be courting disaster to employ men to look after the complicated mechanism of a warship who had no training in such matters, as although they might be good engineers in a general sense, they would be of no practical use in dealing with machinery of which they had no previous knowledge. For example, there are engines and appliances whose motive power was steam, hydraulic, pneumatic, and electric, in connection with the propelling machinery, guns, torpedoes, hoists, lighting, signalling, pumping, &c., each constituted a branch, and each branch required officers and skilled men who were intimately acquainted with their every detail, and when it was realised that the engineer officers of the higher ranks required that intimate acquaintance of the details of every branch, then it was not difficult to conceive how absolutely necessary for efficiency it was that no effort should be spared to make the engineering department in H.M. Navy so attractive as to induce our best engineers, not only to join the service, but to feel so contented and even enthusiastic after joining that they would give their best work to the service of their country. The proposed committee was a great step forward as it would enable the question to be fully considered and so give the members of this and kindred institutions an opportunity of expressing an emphatic opinion upon this national subject.

Mr. D. A. Bremner (by invitation) said that not being a member he might perhaps be allowed to congratulate the Institution on the effective manner in which it had identified itself with this very important question. He regarded the resolutions, which he understood were to be put to the meeting that evening, as significant murmurs which would, he trusted, ultimately swell into a loud note expressive of intelligent public opinion. As an engineer who had devoted considerable attention to the question of engineering in the Navy, he was glad to have an opportunity of completely endorsing all that Mr. Morison had stated in his paper. He could find no trace of either exaggeration or distortion of the actual facts. One great difficuty, in connection with the subject under

discussion, was that its somewhat complex and technical character made it very difficult for the lay public to attain to any full comprehension of the various facts brought to their notice. He, therefore, considered that it would be one of the most useful and important duties of the Engineering Committee, which it was proposed to form, to enlighten public opinion, because "the man in the street" would attach considerable weight to the utterances of a committee of experts, on a question which it was obviously impossible for him to subject to his own personal analysis. He thought that the necessity for thus educating and arousing public opinion was shewn by the remarkable degree of apathy evinced in relation to the question, not only by our Members of Parliament, but by the newspaper Press of the whole country. He referred to the daily Press, and not to the technical and service Press, which had in many notable instances persistently and intelligently advocated the cause of reform. Unfortunately, however, these sections of the Press appealed to but a very small proportion of the people. In his opinion, confidence in our military and naval services varied inversely as one's knowledge of their constitution and operation. The degree of public ignorance which existed made it very easy for the representatives of the Navy in Parliament to indulge in the expression of all kinds of optimistic platitudes. Their statements generally passed unchallenged, and the nett result of this, in conjunction with a great deal of twaddle which appeared in the newspapers, was that the public reposed a degree of unquestioning confidence in the power of the Navy which was scarcely warranted by its actual condition. He did not for one moment wish to advance the absurd proposition that the Navy was generally and hopelessly defective, but he did wish to most emphatically assert that the engineering department in the Navy of to-day was one of the most, if not the most important link in the chain of naval efficiency, and if that one department were defective either in material or personnel, the fighting value of the whole naval organization became terribly discounted.

They could all remember how, on the occasion of the Jubilee Naval Review, the British public indulged in paroxysms of self-congratulation on the ability of the nation to make such a magnificent display of naval power; but those who were able to defy the hypnotic influence of the pageant, and could turn a critical and enquiring eye into the engine-rooms of the fleet, knew that many of the ships assembled in majestic array were not provided with such engine-room complements as would be absolutely necessary in time of war, if they were to undertake naval hostilities with any possibility of approximately realising their paper

values. It might be that the fables which were circulated in this country imposed not only upon our own people but also upon the people of foreign nations. It was not the foreign public, however, but their highly trained naval experts whom we would be called upon to fight, and it was safe to assume that they were perfectly well acquainted with all the joints in our armour. When called upon to engage an enemy, the value of our ships would be measured by their actual performances, and not by those paper values, which had been so often and so carefully scheduled in so-called expert comparisons of the naval strengths of the different nations. That was very clearly shewn in the course of the recent Spanish-American war. Shortly before the outbreak of hostilities *The Engineer* undertook to analyse the fighting values of the two navies, which were shortly to be brought into opposition, with the result that the chances were shown to be in favour of Spain. The spectacle of the 14-knot "Oregon" overtaking the 20-knot "Cristobal Colon" at the battle of Santiago clearly revealed the enormous value of an efficient engine-room staff, and afforded an object lesson which no naval power could afford to ignore.

In the course of the present war in South Africa, they had heard a great deal about the mobility of troops, and he had not the slightest doubt that in the course of the next naval war they should hear a very great deal about the value of mobility of ships.

Mr. Sivewright, in the course of this discussion, had said that the public were to blame for the existing state of things. He quite agreed that, under our representative form of government, the public were to blame, but in varying degrees, according to their knowledge of the question at issue. He held that, in this case, the responsibility fell very directly and heavily upon the engineers and shipbuilders of this country, who had exceptional facilities for becoming acquainted with the facts, and possessed the special knowledge required to draw from them correct deductions. He thought it was a fortunate thing for the country that a representative engineering institution had at last taken the matter up.

The British were not alone in this naval engineering difficulty. It was an unavoidable stage in the evolution of the modern steam navy, and quite recently the United States Government had dealt with the whole question in the bold and drastic manner characteristic of that progressive nation. In future years men would, no doubt, look back with amazement upon the efforts which were now being made to interfere with the natural course of evolution of the steam navy and its highly mechanical armaments, by checking the development of their logical corollary, "the fighting engineer."

He did not propose to expend time in making mere confirmatory comments on the contents of Mr. Morison's very complete paper. He wished, however, to briefly mention one or two additional points in connection with engine-room complements.

The following were examples of the complements of engineer officers carried on ships during the last manœuvres :—

H.M.S. "Andromeda," first-class cruiser of 16,500 H.P., carried 1 fleet engineer, 1 engineer, 2 assistant engineers (each of two years' service), and 3 probationary assistant engineers with no previous service.

H.M.S. "Argonaut," first-class cruiser of 18,000 H.P., carried 1 fleet engineer, 1 engineer, 1 assistant engineer, and 3 probationary assistant engineers having no previous service.

H.M.S. "Howe," first-class battleship of 7,500 H.P., carried 1 fleet engineer, 1 engineer, and 3 probationary assistant engineers having no previous service.

H.M.S. "Nile," first-class battleship of 7,500 H.P., carried 1 fleet engineer, 1 engineer, and 3 probationary assistant engineers having no previous service.

H.M.S. "Trafalgar," first-class battleship of 7,500 H.P., carried 1 fleet engineer, 1 engineer, and 2 probationary assistant engineers having no previous service.

It was surely reasonable to assume that these valuable ships, with their still more valuable freight of human lives, would not have been sent to sea, to participate in manœuvres, with such inadequate complements of engineer officers, if the Admiralty had had at its disposal a sufficient number of experienced men.

In connection with the complements of stokers, it should be remembered that the whole of the men carried were not available for actual boiler room duties.

A number, ranging from 30 to 40 in a large ship were deputed to perform greasing duties in the engine-room, to attend to the various bath rooms and messes, and to act as messengers.

In time of war, on the very numerous occasions when it would be necessary to close the communicating doors between the various compartments of the ship, the mobility of the engineering staff would be very seriously diminished, and it would appear advisable to carry a sufficient number of engineer officers and experienced artificers to enable a competent man to be stationed in the vicinity of each important item of the machinery and armament.

He thought the truth of the whole matter of engine-room complements was that, under the existing conditions, the energies of the engineer officers and experienced artificers were, even in time of peace, very frequently taxed to the utmost limits of human endurance, and that there was therefore no margin available to meet the extra strain which would be thrown on them in time of war.

It was sometimes urged that the institution of such reforms, as were now being advocated, would strike at the root of the whole system of naval discipline, but it appeared to him that discipline must always be founded on justice, and must operate for the common weal, otherwise it became simply an euphonious synonym for tyranny.

He did not place a very high value upon the reserves of engineer officers and skilled engine-room ratings, which they were alleged to possess.

He thought that, if in time of war, the engine-room staffs had to be composed to any great extent of men drawn from that source, their chances of achieving success would be somewhat imperilled.

Rear-Admiral Melville, in writing on the experience gained during the Spanish American war stated that the civilian mechanics who volunteered for duty in the engineering department of the Navy were very inefficient, though he did not in any way wish to cast ridicule upon men who had given their services in a patriotic spirit of self sacrifice, yet there was no use disguising the fact that they had not the special knowledge and experience required to make them really efficient members of the engine-room staff of a warship.

He hoped that the Engineering Committee which was to be appointed would carefully consider the organisation of the Royal Engineering College, and the system under which engineer officers were entered, trained, and subsequently promoted through the various ranks with gradually increasing responsibilities.

There were some features of the training of engineer students and junior engineers which would appear to be susceptible of improvement, whereby the efficiency of the department would be greatly increased.

At the present time there was every inducement for engineer officers to take things as easily as circumstances would permit, as the usual reward of those who were able and zealous enough to attain distinction was an appointment to some particularly troublesome ship, where their lives were made a burden to them, and their future careers were endangered by excessive liability to breakdowns, due to causes which were not always within their control.

On the other hand, the officer who made it his business to follow the line of least resistance, and avoid any extra worry and responsibility, was likely to remain in ships where exceptional energy and ability were not required, with the result that, under the automatic system of promotion, he rose through the various grades of rank and pay, at the same rate as the zealous officer, and managed to have a fairly easy time of it into the bargain.

In engineering circles it was well known that but a very small percentage of those who entered the engineering professions became good engineers capable of filling responsible positions.

In the engineering branch of the Navy the boy who possessed sufficient ability to pass the college examinations generally rose automatically until he became a fleet engineer and found himself in charge of the machinery of a great battleship.

There were doubtless many difficulties in the way of dispensing with some such automatic system of promotion in a public service, but the subject was one which was well worthy of serious consideration.

In his opinion, another very important duty, which should be undertaken by the Engineering Committee, was the formulation of specific questions to be addressed by members of Parliament to the responsible ministers concerned. In reading a large number of Parliamentary debates on service questions, he had been struck by the remarkable ease with which Ministers were able to avoid the real points at issue, but he thought that a committee of engineering experts would be able to draft questions which would defy even officially inspired ministerial powers of evasion.

In the course of this discussion, it had been suggested that the committee should study the conditions existing in the engineering departments of foreign navies, and whilst he thought that a great deal of invaluable information might be thus obtained, he trusted that the committee would not become pervaded with a feeling of contentment with their own state should they chance to find that they were not worse off than some of the other naval powers.

As a nation existing simply by reason of its paramount sea power, it was their duty to lead, and not to follow, in the practical application of those principles which science, practical experience, and common-sense indicated to be most conducive to naval efficiency.

Mr. George McFarlane, of Glasgow (by invitation), thanked the President for the opportunity given him of expressing his interest in the

subject of Mr. Morison's paper. The facts which were brought so clearly before them were so startling even to marine engineers who were intimately acquainted with the conditions prevailing at sea, and the consequences of such a state of matters in a naval war would be so disastrous, that a truly national service would be rendered by the various institutions of this country if the subject were dealt with in the manner proposed by Mr. Morison. He was not empowered in any way on behalf of the Institution of Engineers and Shipbuilders of Scotland, of which he was a member, but he had no doubt whatever that the President and Council would give their hearty co-operation and take up the matter in the same enthusiastic and patriotic spirit as had the North East Coast Institution. He was of opinion that if the Government could be made to realise the dangers involved in the present system that the necessary alterations would be made. The executive staff had practically no engineering knowledge or experience, so that their advice was naturally conservative and prejudiced; but a great awakening would come in the event of a naval war.

The engineers of the nation had no personal ends to serve in this question, as their only desire was to embody in a report their collective opinion on the great national question of the engineering personnel of H.M. Navy with the object of averting possible disasters. It had been suggested that such a report would be disregarded, and that the power of those in authority would be great enough to swamp it, but a wilful trifling with the interests of the nation was not a policy which would be tolerated by those who were responsible for the welfare of this great empire.

Mr. F. W. G. Snook said there was one point in this paper, on page 199, which needed comment. It was "the effect of the policy of repression is discontent, and when parents appreciate the present position they will very naturally dissuade their sons from becoming naval engineers." That was in itself an undoubtedly serious state of affairs, but when, as at present, it was clear that the engine-rooms were undermanned, it would be incurring grave responsibility to appear to agree with the advice that parents should refuse to allow their sons to enter the Navy as engineers. For after all, while the naval engineer naturally regarded his position relatively to the other ranks in the service, that was scarcely the point of view of the parent, who must regard it relatively to the position of the engineer outside the Navy. Everything Mr. Morison had said in this paper was perfectly right and good, and none too

strongly put; the engineer in the Navy was not fairly treated and as the best interests of the country demanded that he should be. But at the same time he thought the parent must consider the question not so much as one of relative rank as of relative well-being for his son. To take the case of a man who entered the service; at the age of 35 years he would have, say from £250 to £300 a year, at 45 years of age he would have, say £400 a year, with a reasonable assurance of retaining it to the end of his life, but whatever his abilities he would get no more. On the other hand were he to remain outside the service he might with luck and ability make many times the amounts mentioned, but it was very doubtful, and he would be of the class of exceptions. Thus the parent, by prudence, was forced to regard the case of the average man, and he (Mr. Snook) questioned whether the average man outside the service would get even as much as those amounts mentioned; but if he did he would have to work to the end of his life, or within a measurable distance of it, whereas at the age of 55 the naval engineer retired. Those were the considerations confronting the parent. As this question was so important and likely to become a national one he thought it well, when this Institution was about to take it up, that there should be avoided all expression of opinion, such as that spoken of, which might be considered as advising or sympathising with an attitude detrimental to the best interests of the country's defence. He thought it would have an ill effect on public opinion, which would presumably have its part to play in this question. The post of "devil's advocate" was never pleasant. He wished it to be clear that he thought the naval engineer was not paid or treated as he deserved to be, and that he simply failed to see the advisability for the reasons stated of parents keeping their sons out of the service. He had no desire that his words should be regarded as in any way combating Mr. Morison's remarks.

Mr. J. H. Buchanan said that he approached the question with some hesitation, as many parts of it required a close aquaintance with the details of service in the Navy, but he considered there was one point on which they as an Institution were specially qualified to express an opinion, namely, that the state of trade had little or nothing to do with the supply of engine-room artificers. The impression that the want of men for these ratings was due to the amount of other employment offering was, he believed, quite an erroneous one. The class of men who were wanted as engine-room artificers would not be readily obtained under the present conditions no matter what the state of trade was.

Doubtless other members had found in their practice, as he had done, that the supply of young men for engagement as engineers in the Mercantile Marine was practically not affected at all by the state of employment on shore, and that those who thought of going to sea would go irrespective of the state of trade. But the fact was that service as engine-room artificers was, in the eyes at least of marine engineering mechanics, hopelessly unpopular. What the conditions would have to be to change this state of things he had no doubt the Committee to be appointed would be able to advise the Admiralty, and he would not attempt to go into details that night, as he believed they, as an Institution, were fully conversant with the means required to secure the type of men wanted in ample numbers. He would like, if Mr. Morison, in his reply, or later, would add some information on the cost of training engineers in several other branches of the profession. He thought the figures on this seemed incomplete. He had been asked by one or two people, after reading these figures, how they would compare with the training of an engineer—say for such a position as Mr. Morison himself held. It would add very much to the value of the paper if he could give that information in the *Transactions*. The paper would become a standard work, he had no doubt, and that information would be most useful.

Communications received by Mr. D. B. Morison :—

BUTE DOCKS, CARDIFF,

DEAR MR. MORISON, *March 24th*, 1900.

I have read your paper with very great interest, and the revelations are so serious that it would appear to be evident that those in supreme power are unaware of the dangers of the position they persist in sustaining. If this is the case, then a system which may bring disaster on the naval power of the nation through technical ignorance should be amended with the least possible delay. It is not to be expected that Admirals can understand marine engineering and follow its rapid developments with the confidence necessary for the highest efficiency of the service, and even if the engineer-in-chief had a seat on the Board of Admiralty he would be in a minority, his opinions would be frequently ignored, and his efforts misunderstood. There should be a representation of the engineering branch on the Board equal to that of the Executive, and at least in proportion to its personnel. Until that is secured, conservative prejudice will stop progress, and some day there will be a terrible exposure when the public will learn too late how great a factor engineering is in naval success.

The committee of inquiry which has just completed its labours was composed not of engineers, but entirely of executive officers and politicians, and although the absurdity and national danger of the present system is known to every engineer who has considered the matter, yet, practically the only result from that elaborate inquiry is an increase of a shilling per day to engineer officers and a paltry adjustment of that meaningless title "relative rank." Surely with such an exhibition as this it is a matter of duty for every engineer to warn his fellow countrymen of the dangers ahead, as only by the pressure of public opinion will it be possible to overcome the intense prejudice which undoubtedly exists.

Yours faithfully,

J. H. HALLETT.

RED CROSS CHAMBERS,
RED CROSS STREET, LIVERPOOL,

DEAR MR. MORISON, *29th March*, 1900.

I have carefully read your paper with the greatest interest, and commend you for taking up a matter of such national importance. I also congratulate you for the able and concise manner, combined with the common sense way in which you have given particulars and expressed your views. It has given me an insight into the position of the naval engineer which I never dreamt of, and I can scarcely credit that such a state of things is allowed to continue. Your paper sets forth everything so clearly and fairly that I cannot see there should be any adverse comment upon it, and I agree with it *in toto*. It appears to me a gross scandal to the intelligence and advancement of this great nation that the Admiralty Board should consist of Admirals who know nothing of engineering, and whose record since the introduction of steam has been one of intense prejudice and most bitter opposition It reminds me of being very much the same as existed in the Mercantile Marine years ago when there was continual friction between the engineering and deck departments. In those days when steamers began to take the place of sailing vessels, the old sailing ship captain, when transferred from a sailing craft to a steamer, naturally had no knowledge of steam or the duties in an engine-room, and frequently called upon a considerable portion of the engine-room staff to perform deck duties when entering and leaving port, irrespective entirely of what might be required below. The obvious result was discontent, decreased efficiency and general demoralisation; but owners soon found out that such a condition of affairs was commercially impossible and the

departments were separated. In the Navy, however, notwithstanding that the evils are more pronounced and more dangerous, there is not only no desire to institute reforms, but the most persistent efforts are made to bolster up a position which is untenable from either a common-sense point of view or from the great standpoint of national interests.

That stupid jealousy should be allowed to play such a part in a nation's safety is incredible, but that is the sole reason why the engineer has not been recognised and his value appreciated; the result is that the fighting power of our Navy, on which such enormous sums are expended, is impaired to an extent, the seriousness of which can only be rightly estimated by the professional engineers of this country.

I therefore enter my strong protest against the present condition of the engineering branch of the Navy and the status of its officers, and will have great pleasure in assisting in any way I can in the efforts you are now making to expose the dangers and promote reform.

Yours faithfully, GEO. HEPBURN.

2A, DRURY LANE, LIVERPOOL,

DEAR MR. MORISON, *May 30th*, 1900.

A perusal of your interesting paper setting forth as it does the plain truth with regard to the engineering personnel of the Navy, clearly indicates that the engineers of this country should so educate public opinion that those in authority will be compelled to realise the dangers surrounding the position.

To those who are acquainted with the facts, it is well known that the engineering branch of the service is at present not very popular, but the wide discussion of your paper will extend the knowledge regarding the unsatisfactory status of engineer officers, with the result that it will be increasingly difficult to get men to join the reserve, and parents will cease sending their sons to be engineer students.

Your paper bristles with points on which much might be said, but as regards complements, I find that, according to Admiralty allowances for manning the engineering branch of effective ships built and building, there is a shortage of approximately 300 engineer officers, 250 artificers, 7,900 stokers, and it should not be forgotten that the Admiralty allowances were based on conditions that existed before the introduction of water-tube boilers, or the great developments in marine machinery and auxiliaries which have taken place during the last ten years, all of which require more skilled attention; so that with the immensely greater I.H.P. a correspondingly increase in the personnel

generally is necessary, particularly in the stoker ratings. If as a moderate basis we take a 25 per cent. increase as being absolutely essential, inclusive of an average allowance of say 7 per cent. for sickness and in hospital, the deficiencies would be, engineer officers 650, artificers 1,100, and stokers 15,000.

In time of war it is idle to expect that patriotism will extend to the engine-room and stokeholds of H.M. ships to the same extent as any other branch of either the Army or Navy, as not only is the work of the hardest and most trying character, but the disabilities of the entire branch are so obvious as to effectively damp anything in the nature of enthusiasm.

To those who are interested in the welfare of the country, and who have taken the trouble to analyse the facts in connection with this subject, the present position produces a feeling of intense depression, for the question naturally arises as to the reason for the persistency with which all proposals or suggestions for reform are blocked, and why it is that the executive branch is so bitterly opposed to the engineers in the service. The answer appears to be that no real progress can or will be made until engineer officers are formed into an executive corps with an effective representation on the Board of Admiralty, and the fact that this is not granted after repeated reports from committees of inquiry seems to indicate very clearly that there is a strong and unreasoning opposition somewhere.

Yours faithfully,

CHRIS. GEDDES.

MR. D. B. MORISON said—Before proceeding to reply to the various criticisms on his paper, he desired to express his appreciation of the interest which had been displayed in its subject by the members of that Institution, and he also wished to heartily thank those gentlemen who had been good enough to contribute to the discussion the valuable and weighty opinions formed upon their own experience and special knowledge. In his reply, as in his paper, he would endeavour to record his views in language which would not be liable to the variable interpretations, so dear to those of our Parliamentary tacticians, who take a seat on the fence until they ascertain on which side it is diplomatic to descend. Their obvious duty as engineers was to give to the nation an expression of opinion on this engineering subject of national importance, and the value of that opinion would be at its maximum if it was fearless, straightforward, and untrammelled by personal or business considerations. Since his paper was submitted to the Institution, he had received letters from a very

large number of well known engineers in this country, America, and on the Continent ; and although there had been a very decided reluctance on the part of the Admiralty contractors to associate themselves with the movement, their President, Sir Benjamin Browne, had set an example of patriotism in this respect of which this Institution might well be proud. The discussion embraced so many points, many of which had been touched upon by a number of speakers, that for the sake of lucidity and brevity, he had thought it best to group his replies under separate headings. In Sir Fortescue Flannery's communication they had many interesting facts, and a manly expression of opinion quite in keeping with his many persistent endeavours in the House of Commons to obtain from the Government a recognition of the dangers which surrounded this great question. It was somewhat difficult to determine Mr. McKechnie's attitude, but he had interpreted his communication to mean that :—(1) The engineering department of the Navy is of essential importance; (2) the alleged elements of inefficiency in that department do exist; (3) Reform is in the highest degree desirable; (4) Direct entry engineers lack the training and the habits of naval life and discipline, which are so essential for the greatest efficiency; (5) Admiralty contractors for naval constructive work are pre-eminently qualified for the successful advocacy of these reforms ; (6) It is a display of unwarrantable pessimism to specifically state, and draw public attention to, the serious defects which undoubtedly exist.

He was glad to find that Mr. McKechnie and himself were in complete accord on the four most important points, but he certainly must join issue with him on his other contentions. He thought they could all safely feel confident that their young naval engineers would under all circumstances do everything which their numbers, natural abilities, training, and experience rendered possible, but this was a very different thing from feeling confident that their naval engineers would, under the particular conditions which now existed, be able to do all that the exigencies of warfare might demand. Apart from the limitations which restricted experience would impose upon the capacities of the younger engineers, there was a limit to the physical endurance of every member of the engine-room staff, from the chief engineer down to the newly enlisted stoker, and if, under what may be termed the more normal conditions of actual warfare, this physical limit was frequently overstepped, the fighting efficiency of the ship must be dangerously reduced.

It was somewhat disheartening to find that anyone who had read his paper could so utterly fail to detect its keynote, as to regard it as a piece

of special pleading for the naval engineers. The national aspect of the question was the one dominant note which he had endeavoured to sound throughout the paper, and he was glad to say that this had been fully recognised by the majority of its readers. It was simply beating the air for anyone to warn this Institution against evils and dangers which, in this particular case, did not exist, and a study of his paper and of Appendix C would reveal that the essential elements of a scheme for "reasonably moderate reform" were clearly set forth.

With reference to Mr. McKechnie's concluding proposition, one was tempted to ask why it was that the pre-eminently qualified naval engineering constructors, if their close association with naval engineers had created in them the same deep interest in the subject of this paper, to which Mr. McKechnie laid claim, had not of their own initiative taken some serious steps to secure the removal of a national danger which lay so entirely within their own special sphere of knowledge.

Mr. Brown asserted that the dearth of engineer officers was largely due to the stiff examinations in mathematics; but in spite of careful enquiries he could not discover that this contention was supported by any ascertainable facts. The mathematical papers in the entrance examination for Keyham were certainly not inhibitive, and it was a rare occurrence for a student to be disqualified after entering the college. As a matter of fact, the number of entries into the engineering branch of the Navy was so limited that the authorities could ill afford to lose even those of very mediocre ability, and backward students frequently received an extra year's training at the college to bring them up to the qualifying standard. It appeared to him that any tuition in the repairs of breakdowns at sea would necessarily be of very doubtful value, inasmuch as in such cases there was nothing certain but the unexpected, and for the effective handling of such emergency work, ripe experience, sound judgment, and ready resource were essential.

With reference to the appointment of engineers "in lieu of chief engineers," he did not say that the young engineers thus appointed were incapable of fulfilling the duties of the higher position, but what he did say was that it was a gross injustice not to confer upon them the higher rank and emolument rightly attaching to the more responsible duties. He completely endorsed Mr. Brown's pertinent remarks regarding the pay of engineer officers, and, as bearing upon the means available for the maintenance of a family at home, he might state that an engineer officer afloat incurred an expenditure for ward-room expenses and subscriptions which it was difficult to keep within the limit of £8

per month, and when this was deducted from the rate of pay set forth in his paper the result was certainly very startling.

Mr. Snook had taken exception to his statement that the effect of the policy of repression was discontent, and that when parents appreciated the present position they would very naturally dissuade their sons from becoming naval engineers. He evidently regarded this passage in the light of advice, and that of a dangerous character, which was being offered to parents. Such, however, was not the correct interpretation to place upon his words, which were simply a commentary on one of the evil results of the present policy of the Admiralty. As the question of deterrent advice had been hypothetically introduced into the discussion by Mr. Snook, he wished to record his belief that very few engineers acquainted with the facts which it had been his endeavour to reveal would consider themselves justified in advising parents to enter their sons into the engineering branch of the Royal Navy. Personally, he would unhesitatingly use his influence to dissuade any bright, high spirited boy from pledging himself to such a career as that which was now offered to naval engineer officers. The flaw in Mr. Snook's line of reasoning lay in the fact that he had endeavoured to express a man's well-being in terms of money alone. They all knew that many other important factors entered into an estimate of a man's welfare. Owing to the very nature of his duties and responsibilities the efficient naval engineer officer must necessarily be an able man of high spirit and strong character. Such men invariably set a high value upon the conditions affecting their self-respect, sense of justice and liberty, and upon the maintenance of a proper relationship between personal responsibility and personal control. If it were wrong and unpatriotic to advise parents not to allow their sons to become naval engineers, then it was equally reprehensible to disseminate the truth regarding the position, emolument and prospects of those officers, because a knowledge of the facts would act as a deterrent in the same way as direct advice. Adherence to such a principle of suppression of discouraging and unpalatable truths would result in the perpetuation of any existing evils in every public department, and he felt sure that it was not Mr. Snook's intention to advocate any such policy.

ENGINE-ROOM ARTIFICERS.

Mr. F. T. Marshall, and certain obviously competent critics outside of the Institution, had stated that in his comparisons of naval and mercantile engine-room complements he had failed to give due recognition to

the value of the engine-room artificers. He trusted that it was scarcely necessary for him to disclaim any deliberate intention of overlooking that most useful and estimable body of men.

He gladly availed himself of that opportunity to express his high appreciation of these members of the engine-room complements of Her Majesty's ships, and he was pleased to be able to state, from his own personal knowledge, that there was no one more ready and anxious than the engineer officers themselves to testify to the value of the work done by artificer engineers, chief engine-room artificers, and senior engine-room artificers. As it was his sole object to submit authenticated facts and to draw therefrom only fair and reasonable deductions, he had given very careful attention to the contentions of his critics, and in this and subsequent sections of his reply he would have pleasure in communicating the results of his investigations. The engine-room artificers were the working mechanics of the fleet, and were recruited from the journeymen employed in the various engineering trades ashore. The candidates must have had an elementary knowledge of reading, writing, and arithmetic, and they were subjected to a more or less perfunctory test of their skill as handicraftsmen. After eight years' service, of which five years must be actual sea time, the engine-room artificer was eligible for advancement to chief engine-room artificer, provided that he was in possession of a certificate signed by the captain and engineer of his last ship, to the effect that he was considered fit for advancement, and that he could pass an examination in arithmetic, practical knowledge of engineering including the action of valves, and the use of indicator diagrams.

Engine-room artificers and chief engine-room artificers were eligible for promotion to the rank of artificer engineer after at least ten years' confirmed service, provided that they could pass the prescribed examination, and were not less than 35 years of age. The number of artificer engineers was limited, and at the present time there were only 75 in the whole Navy. There was no doubt that chief engine-room artificers could rightly be regarded as competent sectional watch-keepers so far as the actual performance of engine and boiler room duties and repair work were concerned, but they were not considered as responsible officers by the Admiralty, except in a limited number of special cases, where artificer engineers were in charge of the machinery in small vessels, which did not carry commissioned engineer officers. Even allowing for this fact, it would be seen that the complements of engineer officers and skilled and experienced artificers carried in our warships were quite inadequate for the duties which they were called upon to perform.

Unfortunately the artificer ratings fell under the ban cast upon the whole engineering department of the Navy, and they suffered from disabilities in connection with pay, pension, and general treatment on board ship, which had so seriously discouraged the most desirable class of candidates that the requisite numbers could only be secured by giving a very elastic interpretation to the Admiralty regulations for their entry.

Sir Thomas Richardson's remarks revealed the true position in a light which was not shed upon it by the Admiralty regulations. In this, as in many other official matters, things were not always what they seemed. At the present time the Admiralty instructions to the responsible recruiting officers discouraged the rejection of any but the most hopelessly unsuitable candidates; the net result being that engine-room complements always contained a considerable per centage of junior artificers who were anything but skilful and reliable assistants, and who were really being trained in the performance, even of the most elementary duties, which they were specially carried to perform. Admiralty champions and partially informed critics, who simply counted heads, and innocently assessed them at their nominal official value, debited these men to the chief engineer, as competent members of his skilled staff.

A very convincing manner of explaining the matter of responsibility would be to quote the following extract from the Queen's Regulations, Article 9, which says :—

If a ship in which there are one or more inexperienced assistant engineers, he (the chief engineer) will make arrangements that all important matters of engine-room duty shall be superintended by himself, or by an engineer officer in whom he can place confidence, and not be left to the care of officers who, from want of experience, cannot be relied on. He is to take every opportunity of instructing the inexperienced engineer officers in the duties of the engine department, and he is to use his best endeavours to make them efficient; with the sanction of the captain he is to take care that any acting engine-room artificers serving in the ship are afforded every facility for acquiring experience in the engine-room to qualify them as watch-keepers.

Part 2 of the above Article says :—

Inexperienced assistant engineers should be trained under senior officers in the duties of stokehold watch-keeping.

The same Article says :—

The senior engineer, those placed in charge of hydraulic machinery and torpedo fittings, and those employed in assisting the engineer officer with his clerical work should keep at least four hours watch per day, and up to eight hours, as may be necessary to ensure the watches being placed in charge of officers.

It would be seen that the obvious intention of the Admiralty was to throw the entire responsibility on the engineer officer, and that engine-room artificers should not be placed in charge, except in those cases where no commissioned engineer officers were carried, or where the number of such officers rendered it absolutely impossible for one of them to be in charge of each watch.

The chief engineer was also instructed not to leave the care of machinery to inexperienced assistant engineers, but a reference to the Navy list, and the examples quoted in the paper, would show that a very large proportion of the staff of officers were inexperienced juniors.

It would be noted that no explanation was given as to how an engineer officer was to keep watch up to eight hours per day in the engine-room, often in the tropics under the most enervating conditions that it was possible to conceive, and also be responsible for the hydraulic machinery, the torpedoes, or the clerical work of the engineering department, without ruining his health by physical collapse.

It had been frequently suggested by champions of the class interests of the executive branch of the Navy that, unless the engineer officers evinced a disposition to acquiesce in the *status quo*, their services might be dispensed with altogether, the duties of the engineering department on board ship being then handed over to the engine-room artificers, under the instruction and command of those executive officers who, in qualifying for gunnery and torpedo duties, had obtained some academic knowledge of physical science, and its practical applications within a narrow sphere. He quite agreed with Mr. Hirst as to the disastrous results which would inevitably attend such a state of things, and that such a preposterous proposition should ever be seriously advanced even by fanatical partisans, was an indication of the very trifling extent to which real naval efficiency and national safety entered into the schemes and calculations of these self-interested gentlemen. What would they say if it were suggested that the gunnery, torpedo and navigation duties should be placed in the hands of warrant officers and first-class petty officers, under the instructions and command of commissioned engineer officers, who had received in the course of their college training, a smattering of academic knowledge of guns, torpedoes and navigation?

Professor Weighton and Mr. Fothergill had very truly said that our engineer officers must be highly educated and thoroughly trained experts, if they were to successfully fulfil their complex and responsible duties.

It was not for him to discourse at length upon the general purposes and functions of officers. Centuries of human experience had revealed

the necessity for their presence in all military and civil organisations, and for their differentiation from the other component elements of the bodies to which they belonged.

It might be that, in the course of routine work under normal conditions, the special mental powers and moral influence of the officer remained to some extent latent, and that their value and real significance were therefore not apparent to the casual observer, but he was confident that no thinking man would deny that their presence was indispensable at all times, and especially so in times of emergency and moments of danger, when men naturally turned to leaders for example, instruction and encouragement.

ENGINE-ROOM COMPLEMENTS.

It would be obviously absurd to construe his comparisons of complements as implying that, in the Navy, all work other than actual firing and greasing was performed by the engineer officers, and had he anticipated that his figures would be so interpreted, he would have set forth with greater clearness the evident value of chief engine-room artificers as sectional watch-keeping assistants. It was not difficult, however, even when this assistance was allowed for, to demonstrate that our Navy was provided with very inadequate numbers of engineer officers and skilled ratings, and it was still less difficult to prove that there was an insufficient supply of officers and skilled ratings possessing the experience and skill requisite to render them really efficient.

He did not think that any of the speakers who had referred to engine-room complements had made sufficient allowance for the great difference in the amounts of auxiliary machinery on warships and merchant vessels, and for the fact that in the former there was a very large amount of mechanism in connection with the armament, for which of course there was no parallel in the latter.

On H.M.S. "Terrible" for example, there was three times as much auxiliary machinery as there was on the R.M.S. "Lucania."

There were also many other circumstances which called for larger engine-room complements in the Navy than were found to be adequate in the mercantile marine.

These points were dealt with in the original draft of the paper, but were subsequently eliminated in the belief that their existence and significance were more generally understood than appeared to be the case.

The machinery on mail steamers, such as those mentioned in his comparisons of complements, was overhauled, repaired, and adjusted in

port at intervals of at the most a few weeks, and on these occasions the ship's engineers received great assistance from a thoroughly skilled and experienced shore staff.

In the Royal Navy, ships on foreign service were only able to visit a dock yard for re-fitting purposes at very long intervals. At all stations, with the exception of the Mediterranean, external assistance was rare and difficult to obtain, and even when a vessel was laid up for a few weeks at any time during, or at the end of a three years' commission, almost all the work was done by the ship's staff, and usually under the disadvantage of having to execute it piecemeal, in order that should an emergency arise, everything could be re-assembled and the ship be ready for sea in from 24 to 48 hours, according to circumstances.

Even in the Channel, where the conditions were necessarily so much more favourable than abroad, theships only went to a dockyard about every six months.

Many competent authorities, having great experience in the Navy, considered it to be of vital importance that Her Majesty's ships should be independent of external assistance for all but the most serious breakages and repairs. Marine engineers would therefore readily appreciate that, under these conditions, the amount of work devolving upon the engineering staff of a warship was out of all proportion to that entailed in the merchant service.

The special character and design of the boilers, particularly of water tube boilers in which there were in many installations upwards of ten thousand steam joints, and also of the machinery on a warship, were such that every part was subjected to far greater destructive influences than were brought to bear upon the machinery in the mercantile marine. At the best, this necessitated closer supervision and the more frequent adjustment and replacement of parts, and at the worst it entailed far more frequent and more serious breakdowns, which taxed the courage, energy, and ability of the engine-room staff to the utmost.

In comparing complements, it must also be borne in mind that the senior engineer, in addition to the chief engineer, could not possibly keep regular watches and yet live, as he had to exercise constant supervision over the whole of the machinery of the ship; that one assistant engineer had the major portion, if not the whole of his time taken up in the clerical work of the department, and that a number of stokers—from 30 to 40 in a large ship—were withdrawn from the boiler-room, about 18 for greasing duty in the engine-room, and the balance for various mess and orderly duties.

In further confirmation of his contentions as to the inadequacy of the engine-room complements, he would state the following authenticated facts :—

Our ships were subjected to quarterly trial runs of 24 hours—20 hours at three-fifths the natural draught horse-power, and 4 hours at natural draught horse-power—and in one of these trials, recently performed by a ship which was classed by engineer officers as "easy steaming," the men during the four hours run were worked in two watches, and the 4 hours for the full N.D.H.P. trial were chosen when considered convenient by the chief engineer at any time during the whole 24 hours of the trial.

He would again ask how it was possible that, under these conditions, the powers of human endurance could be made to extend, to the limit necessary, to maintain the paper speeds of our warships for even one single week at a time.

In most of our new classes of ships, men of the seamen class had to be borrowed in considerable numbers for coal trimming duties, even when running at the ordinary speeds required in manœuvres. It was not apparent how this assistance could possibly be rendered under many of the probable contingencies of actual warfare; for example, when towards the close of a successful chase at maximum speed the imminence of a severe action required the presence of all hands at the posts allotted to them in action by the official watch bill, which did not provide seamen for duty in the bunkers or stokeholds

This shortage of stoker ratings was further illustrated by the examples quoted by Mr. Fothergill in his valuable contribution to the discussion.

On page 195 of his paper, he referred to the iniquitous reduction of the engine-room complements which was instituted by the Admiralty in 1892, in defiance of the most strongly expressed disapproval, not only of the naval engineers themselves, but of the marine engineers and the Press of the whole country. He stated that the total numbers of the engine-room complements were reduced by about 12 per cent., but this did not fully reveal the true significance of the actual changes which were then made, and he now wished to amplify his statement by explaining that a reduction of from 22 per cent. to 30 per cent. was made in the numbers of the engineer officers, and artificer ratings combined, or, in other words, of the mechanically skilled members of the staff. A certain proportion of the engine-room artificers were replaced by chief stokers who could not, by any stretch of

imagination, be regarded as skilled mechanics. The extra number of chief stokers required were provided by accelerating the promotion of the lower stoker ratings. The reason for the institution of this astounding retrograde change was, that the Admiralty had failed to provide the necessary skilled engine-room staffs for the large number of new ships, which were, at that time, added to the Navy, so that the existing personnel had to be spread out thinner in order to go round.

One effect of the change was to throw a considerable amount of extra work and worry upon the chief and senior engineers, the latter, in any sea-going ship, being seldom able to obtain any more leisure than was absolutely necessary for eating and sleeping. In every ship which did the ordinary amount of steaming, abroad or in the Channel, it was usual to have to make special arrangements for granting leave to the engine-room artificers, who got much less leave than the ordinary stoker, who again got less than the bluejackets or petty officers of the other departments.

According to the official watch bill regulating the disposition of the crew, when in action, about one-third of the engine-room staff should be posted at stations outside of the engine-room department.

Our first-class battleships carried 6 engineer officers, of whom there was never more than 1 of engineer rank, in addition to the chief, and in some cases the chief engineer had no experienced assistant, the whole of his staff consisting of assistant engineers. As an instance of this may be mentioned H.M.S. "Royal Sovereign" twin screw first-class battleship, now in the Mediterranean, with one staff engineer and five assistant engineers, two of whom had less than two years' service. Surely it was reasonable to assume that this condition of affairs would not be allowed to exist if the Admiralty had an adequate number of experienced engineer officers at its disposal.

He had purposely refrained from reverting to the comparison of naval and mercantile engine-room complements, because any extended comparison would be of little value, owing to the very great differences in the conditions to be fulfilled in the two services. It would be possible to cite a very much larger number of facts in support of his contention as to the under-manning of the engine-rooms of our Navy, but the above, in conjunction with the subject matter of the paper, would, he thought, be accepted as making out a good *prima facie* case for the subsequent careful consideration of the committee which it was suggested to appoint, and to which he would be able to give additional information.

RESERVES OF ENGINEERING PERSONNEL.

Some of the speakers expressed very sanguine opinions regarding the possibility of providing any required number of reserve engineer officers, and skilled engine-room ratings during time of war. He was very glad to note, however, that Mr. Sivewright and Mr. Westgarth shared his own scepticism with regard to the reality of these alleged reserves.

In his financial statement explanatory of the Navy estimates, 1900-1, the First Lord of the Admiralty stated that the establishment of engineer officers of the Royal Naval Reserve was fixed at 400, the present number borne being 380. The engineer officers of the R.N.R. were drawn from the mercantile marine, and were of senior engineer, engineer and assistant engineer rank, according to their qualifications. Officers of the two former ranks must hold first-class Board of Trade certificates, and have been chief engineer of a British steamer; assistant engineers must hold a Board of Trade certificate, and have served at sea on a British ship for not less than one year as a certificated engineer. Senior engineers and engineers of the Royal Naval Reserve had the option of passing through a three months' instructional course at one of the home dock-yards. During the four years that this regulation had been in force only 8 out of 63 senior engineers, and 13 out of 155 engineers had passed through the instructional course. It was assumed in some quarters that the required reserves of engineer officers and skilled engine-room ratings could be drawn, in time of war, from the following sources :—

(*a*) Mercantile marine.
(*b*) The works of private naval constructors.
(*c*) H.M. dockyards.
(*d*) Mercantile shipbuilding and engineering works.
(*e*) General engineering works.

The men from sources *b* and *c* could not be spared for sea-going service in time of war without striking at the root of our recuperative power, which was so often referred to when it was deemed advisable to emphasize the advantages which we would possess in a naval war, by virtue of our great naval constructing industry. Some of the objections to men drawn from sources *a*, *d*, and *e* were set forth in the paper, but, in view of the vital importance of this question, he might perhaps be allowed to submit some additional arguments against their employment.

The most competent authorities on sea-power were of opinion that,

in view of our complete dependence as a nation on maritime commerce, even for our daily food supplies, it was absolutely essential that we should never lose control of the seas. In other words, our naval strength must be so predominant that, during a war, our merchant vessels could continue to perform their ordinary functions with comparative safety. Failure in any appreciable degree to achieve this object must involve our defeat. This considered in conjunction with the probability referred to by Mr. Sivewright, that in the course of a war we might have to undertake the transport of large bodies of troops, led to the conclusion that, with the exception of a possible small superfluity of inferior men, the engineers of our merchant service would be fully occupied in the performance of their customary duties.

With reference to men from sources *d* and *e* it might perhaps happen that a number would be set free, owing to the restriction of trade accompanying war, but, after most careful inquiry and consideration, he unhesitatingly re-asserted that these men would be of very little value if placed on board our war ships to perform the engine-room duties devolving upon the skilled ratings under active service conditions.

It was very doubtful if our mercantile marine engineers could, without any previous experience on warships, immediately take up and effectively perform the duties of an engineer officer in the Navy. It was not merely a matter of driving triple expansion engines, although even these simple items of machinery, as constructed for the Navy, might sometimes be found to possess somewhat troublesome features ; the difficulties predicted would occur rather in connection with the boilers, the auxiliary machinery, the armament, and the complicated systems of pipe connections, all of which were of a very special character, and required that those entrusted with their care should have given them close study, so as to be quite familiar with all their details, and should also have had prolonged experience in their manipulation and repair, if they were to handle them in time of stress with that confidence, promptitude, and skill which were essential to safety and efficiency.

The discipline and work of the Royal Navy were of a distinctive and peculiar character, and it was extremely doubtful whether the mercantile engineers, with their independent natures and ideas, would cheerfully tolerate much that had to be borne, even in time of peace, by engineers in the Royal Navy ; far less the severe discipline which would certainly be enforced when on active service. In connection with the engineers of the R.N.R. it might be pointed out that, at the outbreak of war, these men would undoubtedly be widely distributed throughout the world, and even

if they could be regarded as efficient reserves it would be impossible to distribute them to the ships within a reasonable period of time. In his opinion it was absolute folly to place any reliance upon the alleged reserves of engineer officers and skilled ratings. It was flying in the face of known facts.

The question of reserves naturally led up to the problem of peace and war complements, and it appeared to him that the only way to secure real efficiency, and to place the Navy in a state of actual preparedness for war, was to provide in all sea-going ships in commission full war engine-room complements of all ranks and ratings, and to institute a system which would provide for the ships of the reserve full war complements of engineer officers and skilled ratings, all of whom had received naval training, and had sea-going experience in H.M. ships.

ADMIRALTY COMMITTEES.

Both Sir Thomas Richardson and Sir Fortescue Flannery had referred to the Committee of Enquiry recently appointed by the Government.

When an official enquiry was held, the natural inference drawn by the public was that the subject would be exhaustively considered by unbiassed experts, and that their recommendations would be adopted.

That this assumption was not warranted by the past history of official procedure in connection with the naval engineers was sufficiently proved by the fate of the excellent recommendations of the Admiralty Committee presided over by Sir A. Cooper Key in 1876, and by the action of the Admiralty following upon the report of the 1899 Committee, which report is asserted by Sir Fortescue Flannery to have been in favour of forming a separate engineering corps, and giving the engineers executive rank. This last Committee consisted of Rear-Admiral Douglas, Captain Prince Louis of Battenberg, and Mr. Macartney, M.P., the Parliamentary Secretary to the Admiralty.

A few engineer officers were selected to give evidence, but it was very questionable whether a *vivâ voce* examination conducted by executive officers would bring out their absolutely unbiassed opinions. Engineer officers had been so subordinated, crushed, and misunderstood at every turn that, rightly or wrongly, they now regarded an individual and true expression of opinion with dread as tending to make them marked men in the service, and so prejudice their careers.

The naval department of the United States had provided a better example of the manner in which such an enquiry should be conducted.

In 1897 the United States Government appointed a Personnel Board

to report upon the causes of the then existing dissatisfaction of the naval engineers, and the friction between the executive and engineering branches, and to formulate a scheme for reform which would establish conditions more conducive to the efficiency of the Navy.

This Board consisted of seven executive and four engineer officers, presided over by Mr. Theodore Roosevelt, assistant secretary of the Navy Department, and reported unanimously in favour of the complete amalgamation of the executive and engineer officers, with one uniform scale of pay and rank, and with uniform powers and privileges. The recommendations were carried into immediate execution. The differences between the two cases were so marked and significant that comment was superfluous.

If "The Influence of Naval Engineers on Warfare" were a subject of trifling importance, one could look on the vagaries of our official procedure with unconcern, but when it was realised that the nation's highest interests were at stake it was simply appalling to contemplate that the position was evidently not understood, nor its consequences appreciated, by those in supreme power.

According to the Parliamentary reports in the *Times*, the following statements were made by the representatives of the Admiralty in the course of the debates on the last Navy Estimates :—

(1.) In reply to a suggestion from Mr. W. Allan, M.P., to the effect that the number of inspectors of machinery should be still further increased, and that chief engineers ought to rank far higher than lieutenants, Mr. Goschen said :—

"The hon. member would wish their promotion to be much more rapid than that of the other branch of the service, though the engineer gets better pay now."

(2.) Mr. Macartney said :—

"As to the position and pay of the engineering branch, he should state that there was no difference between the engineer officer and the ordinary officer of the executive or combatant branch with regard to the power of inflicting punishment. There was only one authority as to punishment on board ship, and that was the commanding officer and the executive officer. The engineer officer was in the same position as the first lieutenant, who had no more power to punish a bluejacket or a marine than the chief engineer. No engineer therefore suffered any disparity of position compared with officers of the combatant branch."

These would appear to be clear statements incapable of being misunderstood, but the language used was Parliamentary, and therefore had the remarkable power of obscuring the essential facts.

Mr. Goschen's statement was only correct if the engineer's pay were referred to the arbitrarily fixed and meaningless basis of relative rank, instead of to length of service, the nature of the duties, and the great responsibilities undertaken.

The true significance of the term "promotion" would depend entirely upon whether it were used with reference to relative rank or rate of pay, and this Mr. Goschen omitted to explain.

The question one naturally asked was, why was it that replies were not given in clearer language. It could not possibly be that our great Ministers wilfully misled the public; it must be, and it was, that they received from those in authority prejudiced and incomplete data.

With reference to Mr. Macartney's statements, it might be explained that the term "executive officer" did not apply to any specific rank of combatant officers. The supreme executive control, carrying with it the power to award punishment, was and always must be vested in the captain, to whom all serious cases were in practice referred; but the actual performance of current executive duties was delegated by him to the officer next in rank to himself. The captain, or in other words the officer in supreme command of the ship, was not, however, always of captain's rank, some vessels being commanded by officers of commander rank, others by lieutenants, and even by sub-lieutenants. It was also a fact that the officer of the watch on deck had power to award punishment no matter what his rank might be. Therefore the executive officer of the day might be, and very often was, the junior in age, length of service, and even in relative rank, of the chief engineer of the ship. The evils, dangers, and inconveniences attending this need not now be reiterated, as they were very fully stated in his paper.

It was therefore an evasion of the facts to say that there was no difference between the engineer officer and the ordinary officer of the executive branch with regard to the power of inflicting punishment. Even a "chief engineer" of "fleet" rank had absolutely no power to inflict punishment in his own department for any offence whatever. If an officer of the military branch were the executive officer of the day, he had power to punish, and if he were not the executive officer for the day, he was only required to state his complaint to an officer of his own branch, who must necessarily be his superior in rank. The chief engineer of a ship was responsible for the work and general conduct of a very large proportion of the total crew, and his men were not only engaged in the performance of special duties which were not understood by the executive officers, but they were located in positions where the

executive officer was quite unable to exercise his personal observation. It was no more subversive to the dignity of the executive officer, and therefore to discipline, for him to be obliged to report his men to a superior officer of his own branch, than it would be for an assistant engineer to report to the chief engineer. It may here be reiterated that the engineer officers desired power only to punish their men for minor offences committed in their own department, it being perfectly understood that their decisions, as those of all other officers, would be subject to endorsement by the captain.

Mr. Macartney also referred to the subject of naval engineers having been dealt with by numerous pamphleteers. It must be assumed that it was not Mr. Macartney's deliberate intention, in using the word "pamphleteers," to discredit by insinuation the persistent efforts of the many able men, and eminent engineers, who had in the Press, and at every opportunity, brought to the notice of their countrymen the dangers which they know to exist. It was once again strikingly evident that our politicians did not realise the true position, and that they allowed themselves to be influenced by the prejudiced views of the executive officers in high power.

With regard to the literature referred to by Mr. Macartney in the House of Commons, there certainly was an amount which was objectionable and discreditable, especially when it was known that it emanated largely from executive officers. One pamphleteer, a Commander, R.N., on active service, considers naval engineering "an alien profession," "in the service but not of it," also as "a lower form of the engineering profession," and compared the engineer officers with the galley slaves of old. Another pamphleteer, a well-known Admiral R.N. (on the active list) wrote of naval engineer officers as being "a scratch collection of the residuum of the engineering profession."

A letter appeared in *Engineering*, of December 1st, 1899, and as it was written in a flippant sarcastic style, altogether unworthy of the subject, he concluded it was from some too enthusiastic cadet, and wrote a reply of protest in the next issue. Sometime after he ascertained that it was well known that the author was an admiral who might some day be on the Board of Admiralty. Realising the incalculable damage which might result from the propagation of such intensely prejudiced views, he decided to bring the subject of his paper before that Institution, so that marine engineers could, with one voice, warn the Government and the country of the appalling disasters which must result, if this great national question were not removed from the intense prejudice and

service jealousies which surrounded it, and dealt with from the standpoint of national safety and national honour.

CONCLUSION.

The discussion had disclosed the unanimous opinion that in the interests of naval efficiency, the engineering department should cease to be included in the civil branch of the Navy, and should be constituted a military corps. This was the keystone of effective reform, and until it was granted the engineering department would become increasingly unpopular amongst the class of young men who were best fitted to become efficient naval engineer officers.

At a time when the machinery and armaments of warships were rapidly growing in magnitude and complexity, and when great skill and knowledge were therefore required on the part of those in whose charge they were placed, the engineer officers were being sacrificed to intense service prejudice in a manner which impaired the naval power of this country to an extent which could now only be realised by professional engineers, but which would most certainly be exposed to the whole world in the next naval war.

In the House of Commons recently Captain Phillpots said: "I can remember the time when owing to a mistaken economy the Admiralty entered men as engineers who were quite unfit for their position as officers, and a great deal of the prejudice which undoubtedly has existed, and still does exist to a limited extent, is due to the fact that in bygone days so many undesirable men were given the position of engineer officers in the Navy."

Therefore by the confession of a supporter of the Admiralty in the House of Commons, it was made quite evident that reforms which were absolutely necessary in the interests of the country were being delayed by prejudices which continued to exist in spite of the fact that the causes which justified them in the first instance had completely disappeared.

It was very gratifying to him to find that his proposal to form a Committee to deal with the great question of the engineering personnel in H.M. Navy met with their hearty approval, and he thought that the knowledge that they had initiated an investigation which might have far reaching effects should be a source of considerable satisfaction to the members of the Institution.

The ultimate result of their efforts would depend upon the manner in

which the Government held the balance between the free, unprejudiced and competent opinion of the engineering professions of the country, and the arguments and advice submitted to them by their official advisers, who, being drawn entirely from the executive branch, were, unfortunately, permeated by the spirit of faction, and whose past actions in the matter had clearly shown that they either did not realise the consequences of their action or allowed conservative prejudice and class interests to interfere with their honourable duty of safeguarding the interests of the country. They, on their part, could do no more than make every earnest effort to ensure that a clear and complete statement of the demonstrable truths relevant to the issue, was placed on their side of the scale. They must then trust to the acumen of the responsible Ministers and Members of Parliament to enable them to detect on which side the preponderance of truth and reason was located, to their patriotic sense of duty to determine their policy in accordance with the facts, and to their courage and energy to carry it into prompt execution.

If it were possible that this committee, embodying as it would representatives of all the great engineering institutions of this country, could become a permanent committee available to be called upon by the Government to report on any departures of moment in the engineering material and personnel of H.M. Navy, it would relieve the permanent officials from a concentration of responsibility so vast as to be inconceivable, and would prevent decisions of possibly vital moment being determined on except after the mature deliberations and report of the representatives of the nation's engineers. Vast sums might thus be saved, increased efficiency would be secured, and the constant bickerings, Press agitations and alarms would practically cease. The great impenetrable barrier of conservatism and red tape blocked the way, but, strong as it was, it must fall by the exposures of a naval war. Then the lay public would realise what engineering meant in warfare, that the paper speeds of our mighty vessels, the area of their coal endurance, and the avoidance of disasters resulting from breakdowns of machinery and armament, were in the hands of those naval engineers, whose persistent warnings were wilfully misconstrued into agitations for personal benefits, and whose worth and work were neither realised nor appreciated. It was their duty to persist in this matter, but if the great barrier still remained impenetrable, then the history of this Institution would show that its members had at least made a great effort to be of service to their Queen and Country.

they did their work thoroughly and wisely. When he said at the last meeting that as the Royal Engineer was to the Army so ought the naval engineers be to the Navy, he was thinking of the early history of the Royal Engineers. Their grandfathers could remember perfectly well when the soldier's artificer, as the Royal Engineer was called, was subject to the interference and control of the sergeant of the line or cavalry. The complaint of his foreman then was that he had not sufficient authority over his men. It was the Army non-commissioned officer who had the authority which the foreman thought ought to be in his hands. The first steps to put that right were taken by the Duke of Richmond and Mr. Pitt. The body was organised and made into a military body, and they had seen two officers of that attain Peerage rank, Lord Napier of Magdala and Lord Kitchener, who was now distinguishing himself at the front, while they could not forget that General Gordon was a member of the Royal Engineers. That was the position to which the present naval engineers might hope that their successors might rise. It was all very well to talk of the minor grievances of pay and so on, but one thing they wanted to see, and he (the President) would not yield to any one present in the great sympathy and admiration he had for the naval engineers, but what was wanted was that as in the case of the Royal Engineers, they should not only be called by the titles of, but that they should really become combatant officers, and that was the one thing that would put them right. He wanted them not only to be called, but really to act as captains and admirals, then all the jealousy would cease between the two departments and they would be fairly and rightly treated, and then only would they take the position that as gallant and educated men they ought to have.

Mr. Henry Withy had great pleasure in seconding the adoption of the resolutions.

The President—Does any one object to any or all of these resolutions ?

There was no objection and the President declared the resolutions carried unanimously.

CLOSING BUSINESS.

RE-APPOINTMENT OF AUDITOR.

Mr. W. G. SPENCE moved the re-appointment of Mr. R. W. Sisson as Auditor. He had held the position for a good number of years, and he thought they could not do better than re-elect him.

Mr. J. R. FOTHERGILL seconded, and the appointment was confirmed.

THE PRESIDENCY AND COUNCIL.

The PRESIDENT announced the result of the ballot to fill vacancies in Council List, 1900, as follows :—

President—Mr. HENRY WITHY.

Vice-Presidents—MESSRS. J. R. FOTHERGILL, J. M. RENNOLDSON, and PROF. R. L. WEIGHTON.

Hon. Treasurer—Mr. G. E. MACARTHY.

Members of Council—MESSRS. R. HIRST, M. C. JAMES, D. R. MACDONALD, T. S. SHORT, and W. G SPENCE.

I have to wish you farewell, continued Sir B. C. Browne. My time as President has come to an end—two very happy and interesting years—and my only remaining duty is to ask Mr. Henry Withy to take my place.

Mr. HENRY WITHY, taking the chair, said he thanked them very much for the honour they had done him in electing him to be the President of this most important Institution, and to assure them that his services, such as they were, should be freely rendered to the society. He trusted to receive the very kind assistance which had always been granted to former presidents, both by the members and the officials, and he hoped that his term of office might be one of benefit to the Institution, and of satisfaction to himself.

VOTE OF THANKS TO EX-PRESIDENT.

Mr. ROBT. THOMPSON had very great pleasure indeed in rising to propose a vote of thanks to their late President, Sir Benjamin C. Browne. It was something like the old saying "The King is dead—long live the King," but, having passed through the Presidency himself, he knew that Sir Benjamin would look back upon these two years with pleasure. Not

only had the discussions been interesting, but the social side, as far as the past President was concerned, had been very successful. They had had the naval architects with them, and he was sure all these meetings tended to make life full of interest and work more precious. Sir Benjamin had presided over the Institution for two years, showing to all that however busy a man might be he could always find time for additional duties, especially of a character that sought to enlarge the intellectual and scientific outlook of his profession. They were two years of useful life, and he was quite sure they, the members, had enjoyed the privilege of having Sir Benjamin as the Chairman of their meetings.

Mr. J. R. FOTHERGILL (Vice-President) had great pleasure in seconding the vote of thanks so ably proposed for their past President, and most heartily concurred in all Mr. Thompson had said. There was one feature associated with the presidential chair not always realised by members, the work done in their Council. Sir Benjamin had been one of the most regular attenders, and wise and prudent in guiding the actions of the Council. He thought those members of the Institution who were privileged to attend the Council meetings would fully endorse this and appreciate the efforts of their past President, Sir Benjamin C. Browne.

The vote was cordially accorded by acclamation.

Sir B. C. BROWNE said he thanked them very heartily for the kind vote of thanks they had given him, but far more than that, he thanked them for their uniform kindness and courtesy and forbearance towards him during the two years he had held office. One of the greatest pleasures of his life had been to help on young engineers, to make their lot easier, and to do anything to enable them to stand alone. He felt very great confidence in retiring from the position that he had held in feeling that he was succeeded by Mr. Withy. The new President was well known to them as a shipbuilder chiefly doing his work in the southern border of their district, but he had extended his actions and was now a Tynesider. He hoped he might have a happy prosperous two years of office and have before him a long and useful career in the shipbuilding world. If his health was spared he was sure they would have cause to be very proud of their new President, both as a valued counsellor and scientific man.

THE RETIRING COUNCILLORS.

Mr. R. WALLIS had great pleasure in proposing a vote of thanks to the retiring members of Council for their very able services during the year.

Mr. JAS. STEWART seconded. The post was no sinecure. He thought they deserved their thanks for giving up so much of their valuable time.

This was carried by acclamation.

CLOSE OF THE SESSION.

The PRESIDENT—As there is no other business I beg to declare the Session closed, and we shall, I hope, have the pleasure of meeting again in the autumn.

MEMOIR.

WILLIAM STAFFORD.

WILLIAM STAFFORD was apprenticed by indenture to Mr. George Fenwick, of South Shore, Gateshead, on the 24th of January, 1863, for seven years. Mr. John Bulmer of Newcastle-upon-Tyne was his foreman. At the end of the period Mr. Fenwick endorsed the indenture stating that the apprenticeship had been served to his entire satisfaction.

On the commencement of the nine hours' strike, Mr. Stafford went to Sunderland and worked for Messrs. Oswald & Co. until he had the misfortune to lose his hand; this happened on the very day the strike was settled.

After his recovery he went into the drawing office of Messrs. T. Clark & Co., Newcastle-upon-Tyne, and thence to Messrs. R. Stephenson & Co., Newcastle-upon-Tyne. He left the latter firm and for some time acted as clerk of works at the sinking of the Redheugh Colliery, Gateshead. Subsequently he held the position of architect and surveyor in connection with the local building trade.

He again entered the employ of Messrs. Stephenson & Co. about the year 1877, succeeding the late Mr. Mordue as chief draughtsman in 1879, and was appointed outside manager in 1898, continuing in that position until his death.

His genial manner gained for him many friends, and his sudden death, which took place on the 3rd day of November, 1899, cast a gloom over a very large circle.